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INCREASING ICE CAPACITY

Addition of an Absorption System to a Compression Plant Increases Ice Capacity 110 Tons Daily Without Extra Boilers or Buildings

SOME OF THE MOST trying and difficult engineering problems come as a result of the growth of a company's business when the original lay out and equipment become inadequate and additional building space is not available. Such circumstances as these surrounded the power plant of the Holt Ice & Cold Storage Co., of Indianapolis, Ind., and the successful solution of the problem as it has been worked out is of more than passing interest, as it is a long step forward in the science of economical ice production.

The principal business of this company is the manufacture of ice for local trade and shipment and the storage of vegetables, fruits, eggs, etc., the storage capacity being about 425,000 cu. ft., this space being cooled by direct expansion. Adjoining the plant in the rear is a creamery which is furnished with all its electric light, power, steam and refrigeration from the Holt Ice & Cold Storage Co.'s plant. On one side the ice plant extends to the railroad right of way, on the other the canal limits the extension while the building extends to the street in front.

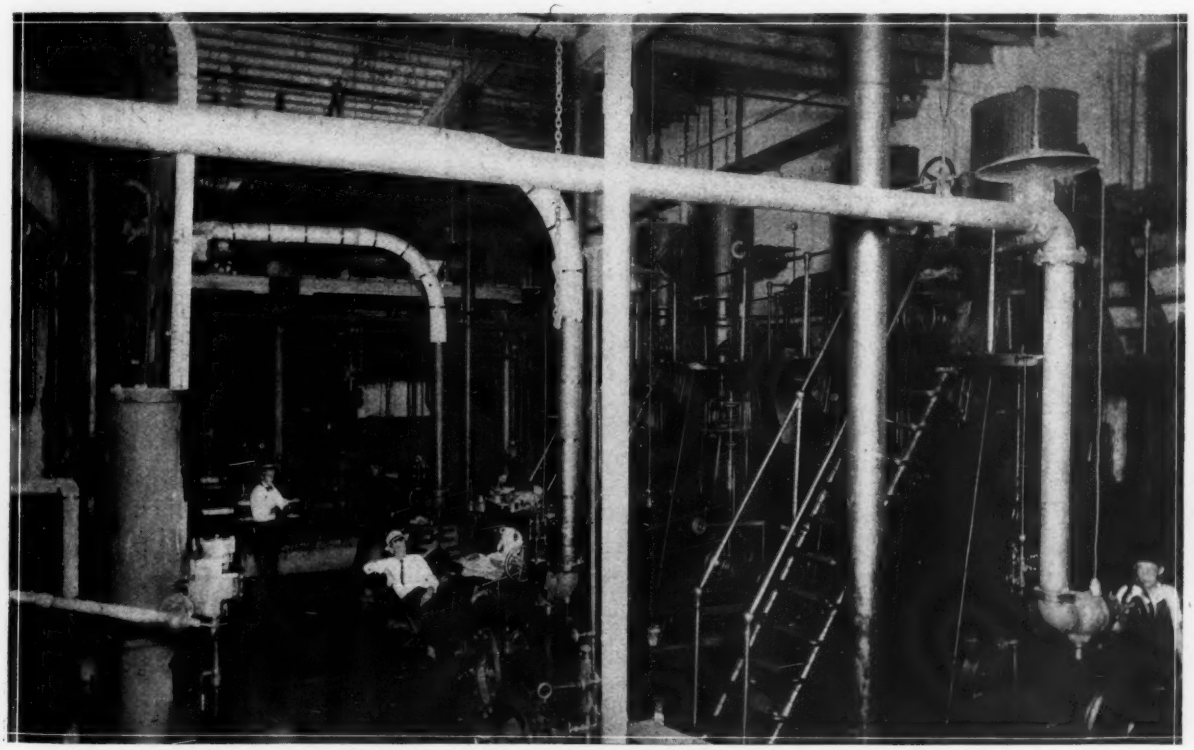


FIG. I. GENERAL VIEW OF THE ENGINE ROOM

Equipment of the Old Plant

THE original plant was installed about 16 yr. ago and contained 2 ammonia compressors made by the Frick Co. These are driven by simple Corliss engines and each has a capacity of 60 tons refrigeration, the steam cylinder being horizontal and 20 in. in diameter and the 2 ammonia cylinders are vertical, each 13½ in. in diameter by 24 in. stroke, single acting, the compressor running at a speed of 65 r.p.m. The pressure carried is from 150 to 200 lb., according to the load on the plant.

Water used for feeding the boilers is first used as cooling water for the steam condenser, after which it is caught in a tank and pumped into the boilers by a 6 by 4 by 6 in. Dean Bros. pump, and 2 10 by 5¼ by 12 in. Knowles boiler feed pumps, the latter 2 being used only in case of emergency.

The ammonia gas from the compressor is piped directly to the loft of the building, where it is passed through an atmospheric type ammonia condenser consisting of 9 stands 24 pipes high and 20 ft. in length. The liquid ammonia is lead to an ammonia receiver in the pit just below the old freezing room floor, this be-

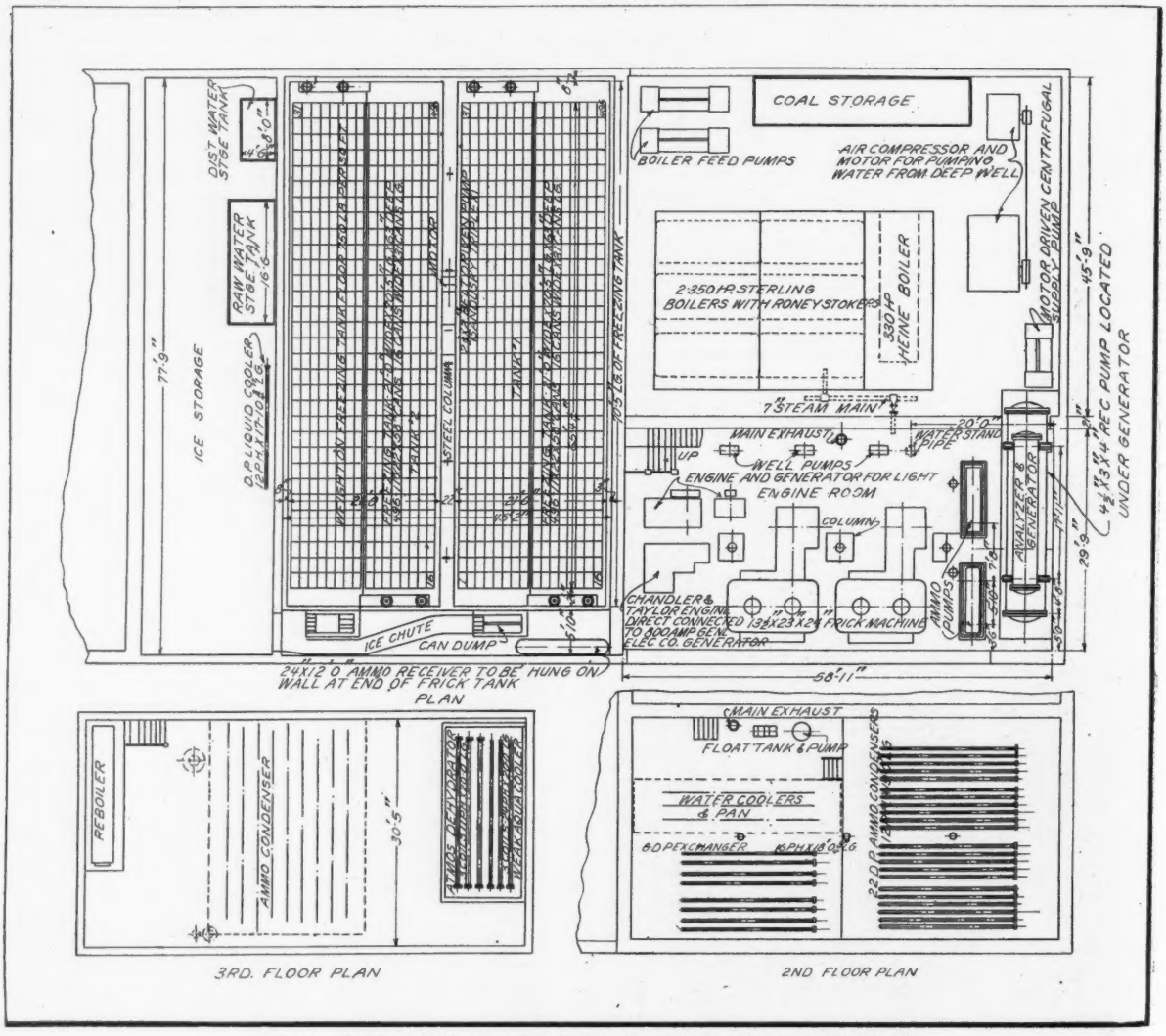

COAL STORAGE
BOILER FEED PUMPS
AIR COMPRESSOR AND MOTOR FOR PUMPING WATER FROM DEEP WELL
MOTOR DRIVEN CENTRIFUGAL SUBSOIL PUMP LOCATED UNDER GENERATOR
2-350 H.P. STERLING BOILERS WITH RONEY STOKERS
330 H.P. HEINE BOILER
7" STEAM MAIN
MAIN EXHAUST
WATER STAND PIPE
WELL PUMPS
ENGINE AND GENERATOR FOR LIGHT ENGINE ROOM
COLUMN
ANALYZER & GENERATOR
AMMO PUMPS
CHANDLER & TAYLOR ENGINE DIRECT CONNECTED 13½ X 23 X 24 FRICK MACHINE TO 200 AMP GEN. ELEC CO. GENERATOR
ICE CHUTE
CAN DUMP
ICE STORAGE
DIST WATER STGE TANK
RAW WATER STGE TANK
O.D. LIQUID COOLER
STEEL COLUMN
705 LIN FT OF FREEZING TANK
24" X 12' 0" AMMO RECEIVER TO BE HUNG ON WALL AT END OF FRICK TANK
PLAN
58'-11"
REC PUMP LOCATED
REBOILER
AMMO CONDENSER
30'-5"
3RD. FLOOR PLAN
MAIN EXHAUST
FLOAT TANK & PUMP
WATER COOLERS & PAN
60 PEX CHANGER
220 P AMMO CONDENSERS
2ND FLOOR PLAN

FIG. 3. PLAN VIEWS OF THE HOLT ICE & COLD STORAGE CO. PLANT

Steam for these machines is furnished at 115 lb. by 2 Stirling water-tube boilers, each being rated at 350 hp. The boilers are equipped with Roney stokers, which are fed by hand from a coal bunker directly in front of the boilers. Recently a new 330-hp. Heine water-tube boiler has been installed. This addition to boiler capacity was made in order that one boiler may be held in reserve, as the water is very hard and boilers must be cleaned frequently. The scale is removed from the tubes by means of a Liberty tube cleaner, which is driven by air pressure.

The boilers are attached to one breeching that leads to a metal stack 130 ft. high and 72 in. in diameter.

ing 24 in. by 8 ft. in dimensions. From the receiver the liquid is forced through reducing valves to freezing coils, thence back to the compressor.

Prior to the installation of the absorption system, exhaust steam from the compressors was delivered to steam condensers of the Sellers Flask type, after having passed through an efficient oil separator. Now the exhaust steam goes to the generator and all the condensate is delivered to the reboiler, after which it passes through a distilled water cooler of the atmospheric type consisting of 4 stands of 3-in. pipe, 17 pipes high and 22 ft. in length. This distilled water is then delivered to the storage tank or forecooler in

the old freezing room through a number of carbon pressure filters.

In the old freezing room are 2 tanks which accommodate 720 400-lb. cans, and the capacity of the tank is 60 tons in 24 hr. The brine is circulated by 4 brine circulators driven by belt from one motor. These are screw propellers, 2 being placed at one end of each tank, thus circulating the brine down one side of each tank and allowing it to return by the way of the other side.

Distilled water from the condensing system is used in filling the cans, which process is done by means of Burns automatic can fillers. For lifting the ice cans out of the tanks 2 hand-operated hoists are employed by means of which the cans are taken to the can dumps, thence the ice is delivered to the storage rooms through gravity chutes.

Water Supply

WATER used about the plant is taken from deep wells and the canal. For drawing the water from the wells, which are 70 ft. deep, 3 A. D. Cook deep well pumps are used. In addition to these an air lift well 400 ft. deep is employed, using air at 75 lb. and at full capacity, 293 cu. ft. a min. The air compressor used for this purpose was made by the Advance Steam Pump Co., and is belt driven by a 65-hp. General Electric Co. motor. Water is drawn from the canal by a 7 by 8 by 12 in. Dean Bros. duplex pump during fall and winter months, when its temperature is low.

A cement receiving basin is placed under one end of the boiler room floor and has a capacity of 5500 gal. From this basin all circulating water used for cooling purposes is drawn by a centrifugal motor driven pump with a capacity of 700 gal. a minute, the motor having a capacity of 30 hp.

The original electrical machinery consisted of a small Commercial Electric Co. d. c. generator, used principally for lighting; this is belted to an Eclipse center-crank engine and generates electricity at 110 volts being capable of delivering 300 amperes, the speed being 835 r.p.m.

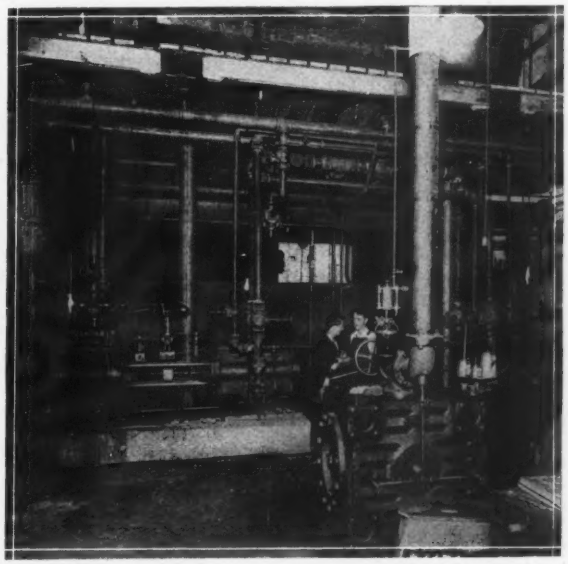


FIG. 2. ABSORPTION MACHINERY IN THE ENGINE ROOM

How the Plant was Enlarged

INCREASED demand for ice taxed the capacity of the plant to such an extent that it was unable to supply all that was needed, and the idea was conceived to install an absorption plant to use the exhaust from the compression machines. By this arrangement the combined plant is not only able to make more ice, but to use the steam already generated to best advantage.

The question of space in which to install the new equipment was quite easily solved in this case, as

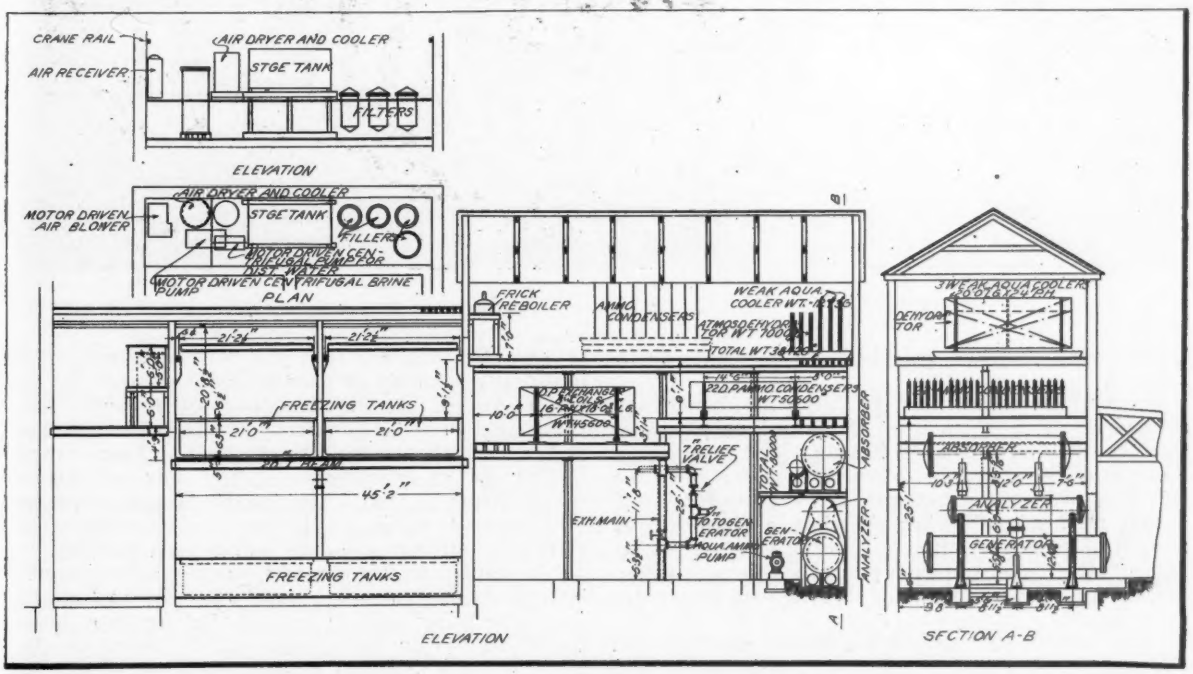


FIG. 4. ELEVATIONS OF THE ICE PLANT

absorption machinery does not require a great amount and there are no large moving machines requiring heavy foundations; also the arrangement of the machines of the absorption system is very flexible since they do not require a strictly relative position.

The new equipment was furnished by the York Mfg. Co., the generator being of the horizontal welded steel shell and coil type, as shown in Fig. 2, and is heated by exhaust steam from the Frick compressors, all of which is not used but by means of a back-pressure valve, a pressure not to exceed 3 lb. per sq. in. is maintained in the generator. Directly above the generator, as will be seen in the illustration, is the analyzer of the horizontal welded steel type. The dehydrator is placed in the loft above the generator as shown in the elevation, and is of the atmospheric type, made up of 3 in. pipe into 3 stands 11 pipes high and 20 ft. long. The gas from the dehydrator goes to the ammonia condenser located on the second floor. This is of the counter-current, double-pipe type, made up of 2 and 1½-in. pipes into 22 stands 12 pipes high and 19 ft. long.

Also on the second floor is placed the double-pipe exchanger which is made up of 2 and 3-in. pipe into 8 stands of 16 pipes each 18 ft. long. The weak liquor cooler is of the atmospheric type and is located in the loft, from which the weak liquor flows to the horizontal welded steel tube absorber placed on a platform just above the generator. Beside it is the strong aqua receiving tank. The ammonia pumps for the absorption system are 2 in number and are located beside the generator.

It is notable that though the former plant seemed well filled with machinery the only needed addition to the building was the raising of the roof over the freezing tank and placing on the second floor the new freezing tanks. These tanks are shown in the plan Fig. 3, and Fig. 5 is a view in the freezing room. Each of these 2 tanks contains 496 400-lb. cans, the total rated freezing capacity of the new system being 110 tons in 24 hr.

At each end of each freezing tank are 2 motor driven brine agitators. The motors are of the vertical type run on 110 volts, each having a capacity of 3 hp. These agitators give excellent circulation to the brine which is kept at 15 deg. F.

Freezing being done on the flooded system, each tank is provided with 2 accumulators. By this system the results have been much better than those obtained by the former plant. The ammonia is allowed to flow through the coils, then all liquid remaining is caught in a trap, passed through the accumulator and through the coils again with the fresh liquor, while the gas passes to the generator.

In this freezing room are 2 traveling cranes used to lift the cans out of the tanks; they are motor driven and each is designed to lift 2 400-lb. cans. In one end of the freezing room are 2 can dumps of the automatic quick closing type.

This freezing room being on the second floor, ice must be lowered to the first floor for loading onto wagons and delivery into the storage rooms. The lowering is done by an automatic device made by the Gifford-Wood Co., which, without other power than the weight of the ice, lowers the blocks, dumps them and returns the carriage to the second floor without jarring the ice or excessive speed. The principle of its operation is that when the ice is being lowered it compresses air in a cylinder which is sufficient to return the carriage when the ice has been dumped.

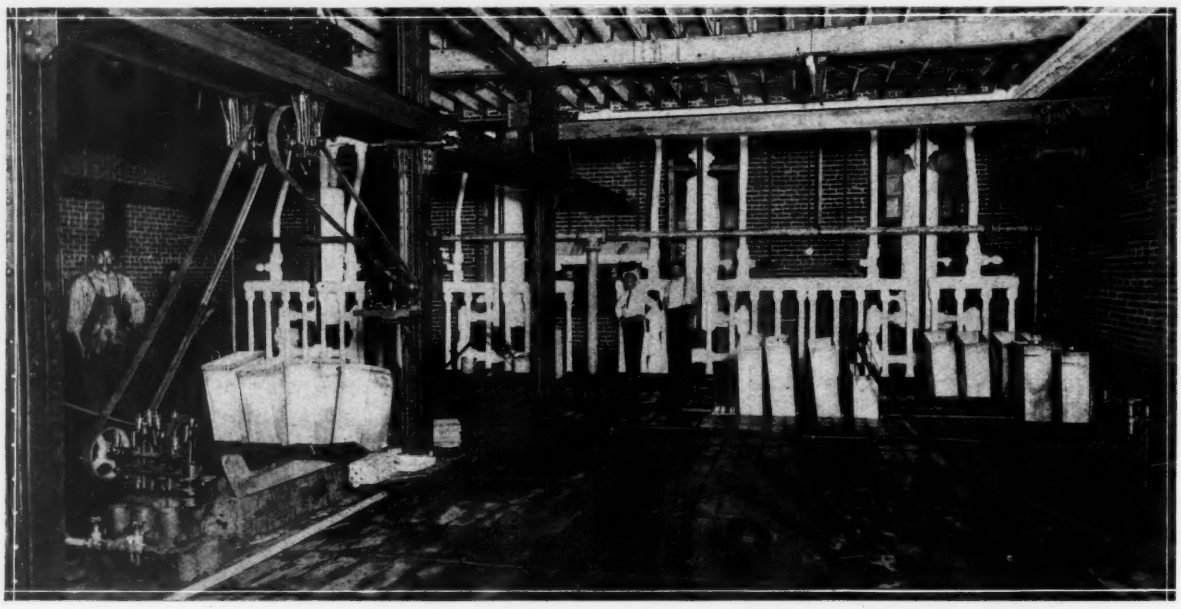


FIG. 5. VIEW IN THE NEW FREEZING ROOM

An important problem in connection with this new equipment was to secure pure water for making the ice. The water used in the old freezing room is the condensation from the exhaust of the compressors, but there is not a sufficient amount of this to supply the new system as well. It therefore became necessary to use raw water and the difficulties encountered here have been the most stubborn to overcome. Well water in the community of Indianapolis is very hard and ice made from it without provision for purification has a bitter tasting core. The method employed for remedying this difficulty during the past season has been to

supply the tanks with an air circulating system consisting of a motor driven air blower, combination air washer, drying and cooling tank and the necessary air laterals and drop pipes to cans. This air keeps the freezing water in circulation and prevents the impurities from freezing into the water until the core is reached, when the air agitation is stopped and the remaining water withdrawn, its place being filled with distilled water from the compression system.

Before passing to the cans the raw water is stored and cooled in a 100-ton tank provided with direct expansion coils. The distilled water is stored in a 25-ton tank provided with necessary expansion coils.

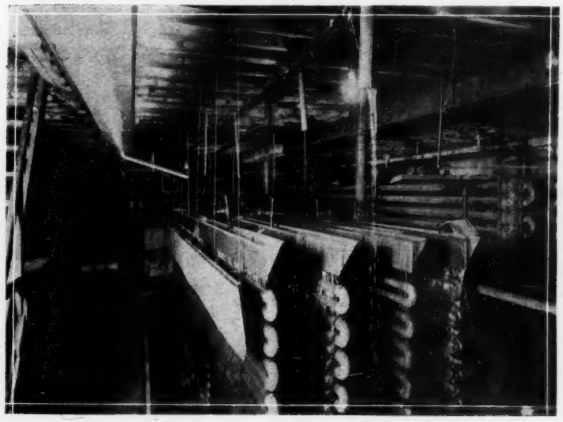


FIG. 6. OLD DISTILLED WATER COOLER WITH NEW EXCHANGER TO THE RIGHT AND NEW AMMONIA CONDENSERS IN REAR

Recently a water softening system has been installed by means of which 2000 gal. of water can be treated an hour. This will be used for all purposes where water free from impurities is desirable. The softener was made by the William Graver Tank Works, of Chicago.

During a visit to this plant one is impressed by the contrast between the old and new methods of performing the same operation. While 16 yr. is not long in history, the changes that have taken place in ice manufacturing equipment and methods are many, and to see the up-to-date plant of 16 yr. ago working beside that of today impresses the engineer with the importance of continual study and research if he expects to be a man of today instead of that of yesterday.

Not only does this plant possess a new refrigerating dress, but present day ideas in motor driven equipment made necessary the installation of a new generating unit which consists of a Chandler and Taylor engine, 15 by 14 in., direct connected to a General Electric Co. d. c. generator of 800 amp. capacity at 125 volts, running at 260 r.p.m. The switchboard has 3 panels equipped with necessary instruments, switches, etc.

It will be noted that although the plant has practically doubled its refrigerating capacity by the additional machinery, no extra boiler capacity is needed, little extra attention to machinery is required from the engineer, the principal extra operating expense being in taking care of the new freezing room, which, with its modern equipment, is readily handled by one man.

While this method of increasing refrigerating capacity is comparatively new, it has been used to excellent advantage in a number of cases and bids fair to become standard practice in plants of this character. The superintendent of the plant is W. S. Ballenger, whose energy and enterprise have brought about the desirable additions to this plant.

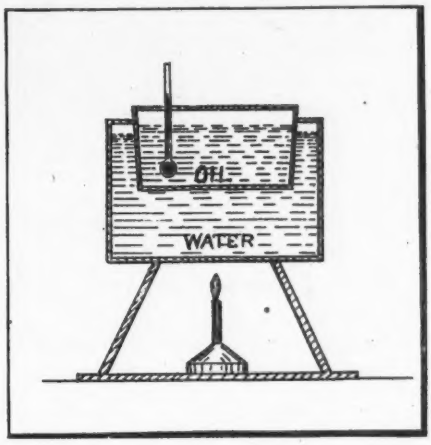
TESTING OILS

THERE are several tests which anyone can apply without the use of special apparatus, and tell something about the grade of lubricating oil he is getting.

To find the flash point, place a small amount of the oil to be tested in a pan, as indicated in the accompanying illustration, and heat by means of the lamp beneath. As the oil heats, pass a match above the surface. After a time a flash is seen when the match is applied, but it disappears as rapidly as it came. This shows that enough vapor had been produced to mix with the air and form an explosive mixture. The temperature, given by thermometer, at which this occurs, is called the flashing point. At some higher temperature, if a match is applied, the oil takes fire. This latter temperature is known as the burning point, and may be a considerable number of degrees above the flashing point.

To Detect the Presence of an Acid

DISSOLVE a small amount of sodium carbonate in an equal volume of water. Place it, together with the oil to be tested, in a flask beaker and shake thoroughly. The quantity of precipitate will be a gage of the amount of acid present.



APPARATUS FOR TESTING FLASH POINT OF OILS

To Detect the Presence of Grit

DROP a small amount of the oil on white or very light-colored blotting paper. The oil will be absorbed, and the grit will be visible as small black specks on the blotter.

FORTY THOUSAND HORSEPOWER to be sold at $20 per horsepower per year is the project now under consideration involved in a hydraulic plant development at Muscatine, Ia. This will involve a dam in the Cedar River near the Tice bridge, and a tunnel 2 miles long; it also includes plans for an interurban railroad from Muscatine to Iowa City, connecting with the line from the latter city to Cedar Rapids.

AIR COMPRESSORS

Types and Details of Construction

USE of compressed air as a medium for transmitting power has grown rapidly during the last decade in spite of the fact that operating data is lacking in many applications and that in many instances almost utter disregard for efficiency is apparent in the design of air-using apparatus. The last statement cannot be applied, however, to air compressors, for these machines have received the most careful study and in every detail, compressors have reached a high degree of perfection.

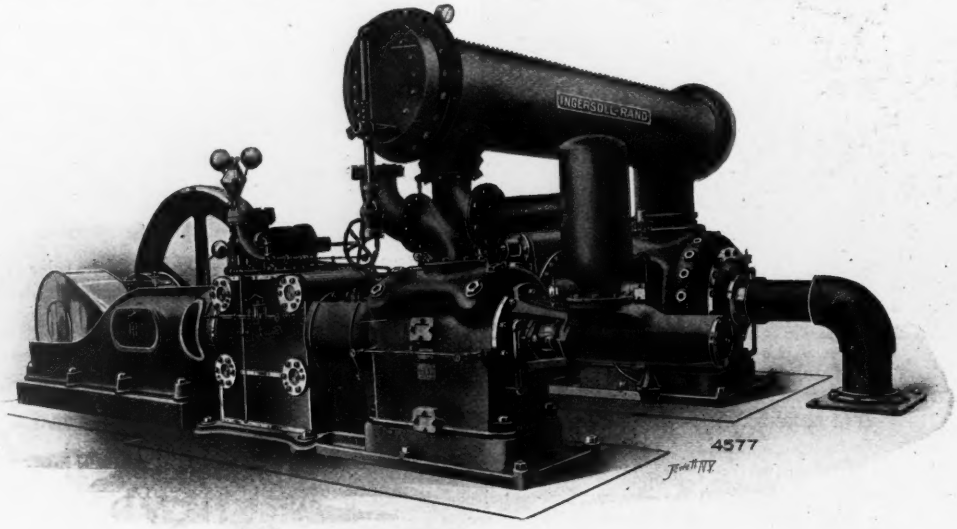


FIG. 1. STEAM DRIVEN, DUPLEX, CROSS-COMPOUND, 2-STAGE AIR COMPRESSOR

Power to Compress

COMPRESSION of air may take place under one of 2 conditions or some condition between these 2 limits. The first of these is compression without change of temperature and is known as isothermal. To obtain isothermal compression it is necessary to supply some means for removing the heat which is due to the mechanical energy expended in reducing the volume of the air. This condition in practice is never fully obtained owing to the speed with which the air must be compressed and the volume of the cylinder being too large to allow all the air to come in contact with cooling surfaces. It is however aimed at by providing water jackets and where more than one stage compression is employed intercoolers reduce the air to the temperature of the atmosphere on lower.

The other extreme called adiabatic compression, is to retain all the heat of compression in the air. This condition requires more power than isothermal compression since by raising the temperature without changing the volume the pressure is also raised. Since in practical compression of air some radiation is sure to take place adiabatic conditions do not exist.

In practice the power required for compressing air is calculated in a similar manner to that employed for determining the horsepower of a steam engine. In other words, the horsepower required for compression is calculated from an indicator card and is equal to the mean effective pressure multiplied by the area of the cylinder, times the piston speed in feet per minute, divided by 33,000. Theoretically, however, this would be obtained by use of the following rule: Divide the final pressure by the initial pressure, both given in pounds per square inch, absolute; raise this quotient to the 0.2857th power and subtract 1; multiply the result thus obtained by 0.000,005,999 times the initial absolute pressure, times the volume of air in cubic feet at the initial pressure delivered per minute: the result will be the horsepower required for single-stage compression without a water jacket on the cylinder.

With any of the means employed for compressing air, compression may take place in 1, 2, or 3 stages. Single stage compression is raising of the pressure from atmospheric to the final pressure in one operation by one cylinder; this means is employed most economically in low pressures not exceeding 75 lb. By 2 stage compression is meant the raising of the air pressure in 2 steps, or by 2 cylinders, the low-pressure cylinder delivering the air at about half the final pressure to the high-pressure cylinder which raises the pressure to that desired in the receiver. This means is employed where high pressures are required, ranging from 60 to 125 lb. For extremely high pressures 3 or more stages are employed in which several cylinders are used through which the air is passed successively.

Air cylinders may be single or double acting, according to whether they compress during both strokes or during only one stroke of the cycle.

The most logical classification of air compressors seems to be in regard to the method of driving and arrangement of cylinders, due to the fact that a selection of any particular type of air compressor will depend largely on the method of driving, since the service is controlled by this feature. The characteristic

features of various types of compressors will therefore be taken up in the following order: Steam driven gasoline engine driven, power or belt driven, electrically driven, and, in a separate class, centrifugal compressors.

Steam Driven Compressors

IT is a notable fact that in the development of large air compressors the horizontal type has received most attention. In Fig. 1, is shown a compressor of this type which has a number of characteristic features. It is of the duplex type with Corliss steam cylinders next to the frames and separated from the air cylinders by open distance pieces. It is known as the class O C compressor, built by the Ingersoll-Rand Co. This machine is of the 2 stage type with the intercooler placed transverse and above the cylinders.

Automatic control of speed and pressure, and regulation of output to load are secured by means of the governor. This is a combination of the ordinary flyball speed governor driven from the main shaft with a pressure regulating cylinder connected to the receiver. The flyball element is a speed limiting device preventing the machine from going beyond a safe number of revolutions per minute. The pressure piston operates, when normal air pressure is exceeded, to change the cutoff and thus reduce the speed and output of the compressor under partial load. A weighted lever opposing the pressure piston restores the speed and cutoff as load increases.

Air cylinders are made with a full box construction underneath, the entire box being a part of the water jacket and serving as a settling chamber. Where it is impossible to get clean water for jacket cooling, this settling chamber prevents the jacket space from filling with mud or scale and maintains the efficiency of the jacket cooling. There are no valves in the air heads, which are completely water jacketed. The manufacturers contend that the head jacket is most efficient since air in the cylinder is in contact with the head throughout the entire stroke, and for this reason the coolest water is passed through both air heads before going to the cylinder jacket.

Water enters the bottom of each head and flows out at the top through a pipe to the bottom of each end of the cylinder jacket. A single water discharge is placed on the side of the cylinder at the top of the water space, this being piped into an open funnel connected with a drain pocket cast on the cylinder sole plate. Thus the flow of water is always visible and can be regulated properly. Efficient means for draining is provided by a large drain valve for the cylinder jacket and a single drain valve on both heads and for water piping, all these drains being piped directly to the main cylinder drain.

Air discharge passages are exceptionally large and free, the low-pressure discharge being one-half the area of the low-pressure cylinder. The discharge valves are arranged radially in the cylinder barrel, and are of large size so that the removal of 1 or 2 permits inspection of the interior of the cylinder.

A distinctive feature of the Ingersoll-Rand compressor is the inlet valve which is of the Hurricane-Inlet pattern, the principal feature of which is the piston inlet. Each piston carries 2 ring valves, one on each face; each valve is a simple ring of oil-treated steel forged without welds, holes, slots or weak places, from a solid billet and turned to a light, uniform T section. The inlet port is an annular opening in each piston face, of large area and free from obstruction so that its entire area is effective.

Bolted to the face of the piston is a steel guide plate with a series of large openings just within its circumference. The ring valve rests loosely upon the guide plate and the piston face, the bar of the T forming the valve face and the upright of the T the guide section sliding on the guide plate. The travel between the valve plate and piston is the lift of the valve. The construction is identical on both faces of the piston. The 2 valves travel with the piston, the one in front closing by its inertia and remaining closed under the air pressure in advance of the piston. The other valve, assuming that this is the first stroke, drops back against the guide plate the moment the piston starts, making full valve opening which is maintained until the piston stops when this valve continuing in motion slides gently to its seat. On the return stroke the action of the valve is reversed.

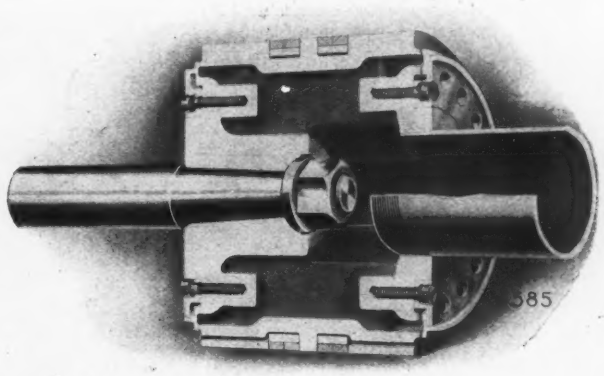


FIG. 2. HURRICANE-INLET VALVE PISTON IN SECTION

The valve is double-ported, air entering the cylinder outside and inside the ring valve through the openings in the guide plate. By this arrangement an air inlet area from 12 to 15 per cent of the total cylinder cross-section is obtained.

The Hurricane-Inlet valve used on these compressors lends itself with peculiar readiness to arrangements for admitting cool, clean air to the cylinders. The atmospheric intake which is commonly used is intended for handling free air only. It is made with a cast footpiece for bolting to the floor or foundation; there is no stuffing box, but the horizontal pipe surrounding the intake tube is closed with a brass collar just clearing the tube, giving an almost air tight connection.

Duplex air compressors have advantages which make them applicable in places where a wide load range is necessary; balanced construction with quartered cranks effecting an equalization of impulses and a mutual co-operation between the 2 halves of the compressors; reduction of operating stresses by this balanced construction; absence of any dead center admitting of automatic and economical operation over the entire load range; ease with which either or both steam and air cylinders can be compounded, securing the attendant economy without an increased number of parts.

Unloading

IN cases where speed of the compressor must remain constant, as in power driven machines or in steam driven machines furnishing power for other purposes, it is necessary, in order to avoid waste of power when the air pressure exceeds the required limit, to stop

further delivery of the air until the pressure falls to the required limit. This may be accomplished in several ways and that of unloading the compressor is considered one of the most efficient. In Fig. 3 is shown the means applied on Allis-Chalmers compressors for maintaining constant pressure or constant speed. An air pressure pot is connected to knockoff levers on the inlet valve bonnet so that a slight increase in the air pressure actuates the knockoff lever, bringing a cam under the heel of a spring hook, thus releasing the inlet valve from the motion of the air lever, the mechanism being exactly the same as the Allis-Chalmers Corliss releasing gear. In this way the inlet valves are kept open, permitting air to pass in and out again without any compression having been performed.

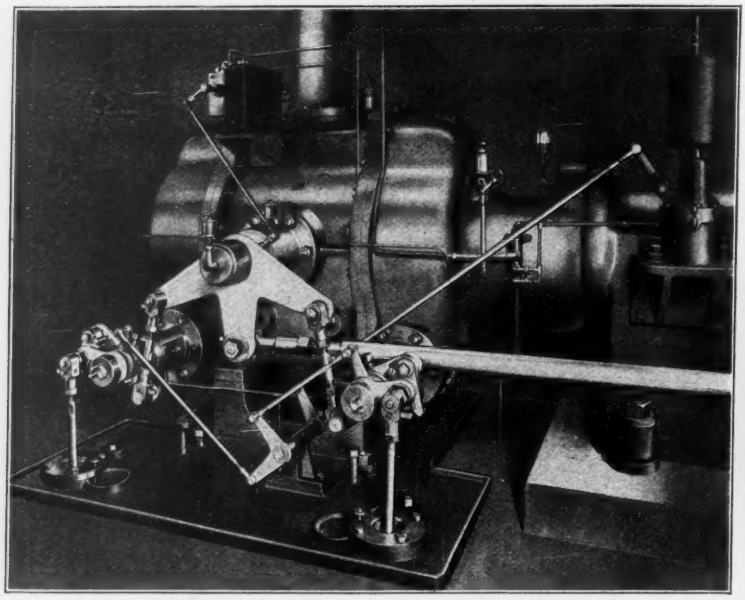


FIG. 3. UNLOADING DEVICE USED ON STRAIGHT LINE ALLIS-CHALMERS COMPRESSORS

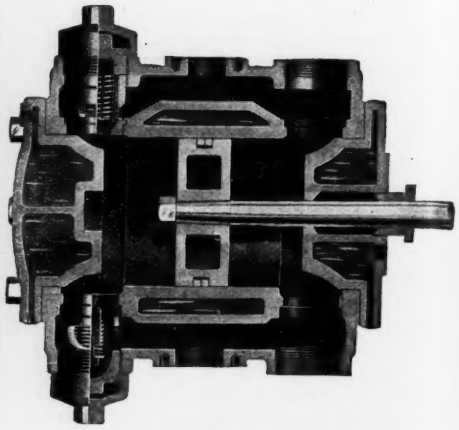


FIG. 6. SECTION OF AIR CYLINDER SHOWING METHOD OF WATER JACKETING

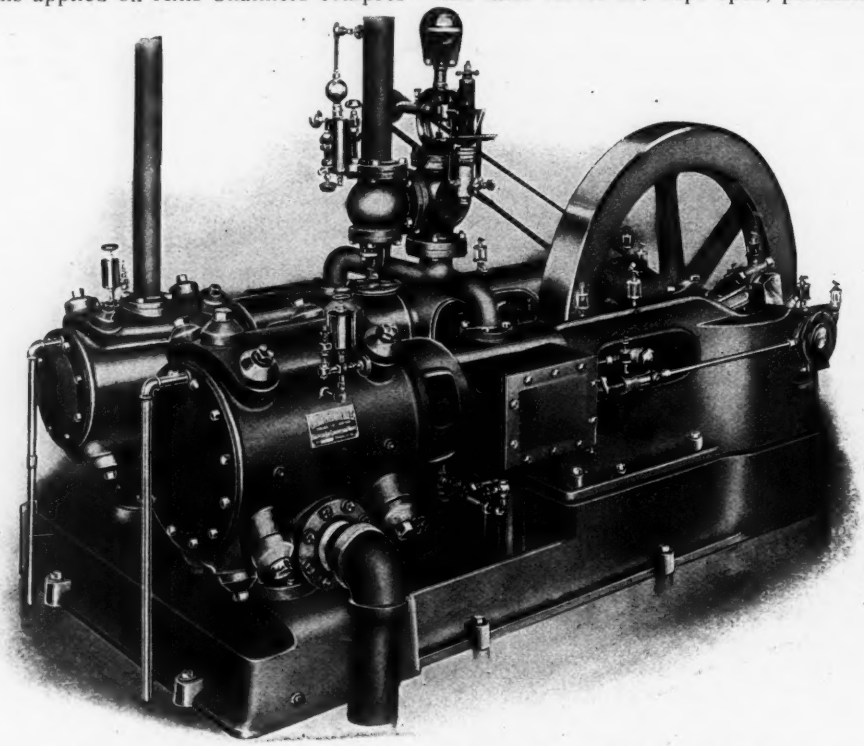


FIG. 5. CHICAGO PNEUMATIC DUPLEX STEAM 2-STAGE AIR COMPRESSOR

It will be seen from the illustration of this air cylinder that the inlet valves are located below the

piston level and removed from the heat zone, thus insuring the least possible increase in the volume of incoming air due to rise in temperature. The discharge valves are located in the head of the cylinder covering almost the entire surface of the cylinder head. The cylinder is water jacketed around the barrel, but in view of the entire cylinder head being given up to discharge ports, it is impossible to water jacket these heads, which on account of the greatly increased radiation surface of this type of head is considered unnecessary by the manufacturer.

The working barrels of this air cylinder are not cast in one piece with the cylinder proper but are separate, the cylinder casting being accurately bored and the liner accurately turned to fit and forced into place, the space between liner and outer walls of the cylinder forming the water jacket. This construction insures freedom from casting strains. Large cleaning holes are provided so that the water spaces may be thoroughly cleaned out whenever necessary.

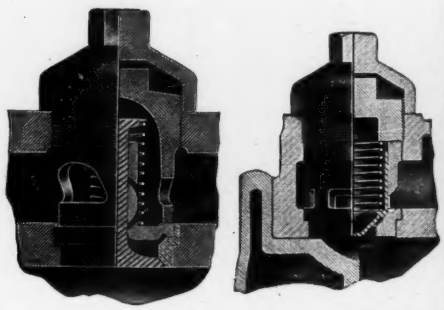


FIG. 7. POPPET INLET AND DISCHARGE VALVES OF THE CHICAGO PNEUMATIC AIR COMPRESSOR

The Corliss valve, which is employed in these compressors for the inlet valve, is especially well suited for compressor use in that it affords a quick, free opening and admits air in a thick unbroken stream, while at the same time a small proportionate surface of the heated metal is exposed to contact with the incoming air. The inlet valves are driven by an eccentric on the main shaft and, by means of the wrist plate mounted on a stand on the side of the cylinder, are given the quick opening and closing and slow movement when the ports are covered and the valves under pressure which are characteristic of the Corliss valve gear.

Discharge valves are of the drawn steel cup type and open automatically when the pressure in the cylinder equals the discharge pressure. They are easily accessible for inspection and may be readily removed for cleaning and put back again without trouble. The inlet valves may also be removed without disturbing the connections or the adjustment of the valve setting.

The usual method of arrangement of cylinders employed by the Allis-Chalmers Co., in steam driven compressors is to have the steam and air cylinders placed in tandem, the particular arrangement adopted in any case depending upon the style of compressor, type of air cylinder, and conditions of operation.

In ordinary operation of a compressed air plant, the amount of work being done and consequent quantity of air being used is continually changing, while the pressure must be kept as constant as possible. In compressors driven by steam power and where no power is taken from the steam end of the machine for other purposes requiring constant speed, constant pressure is maintained by an especially designed air pressure regulator by means of which the speed of the air compressor is automatically varied according to the amount of air required, thus making possible a constant air discharge pressure.

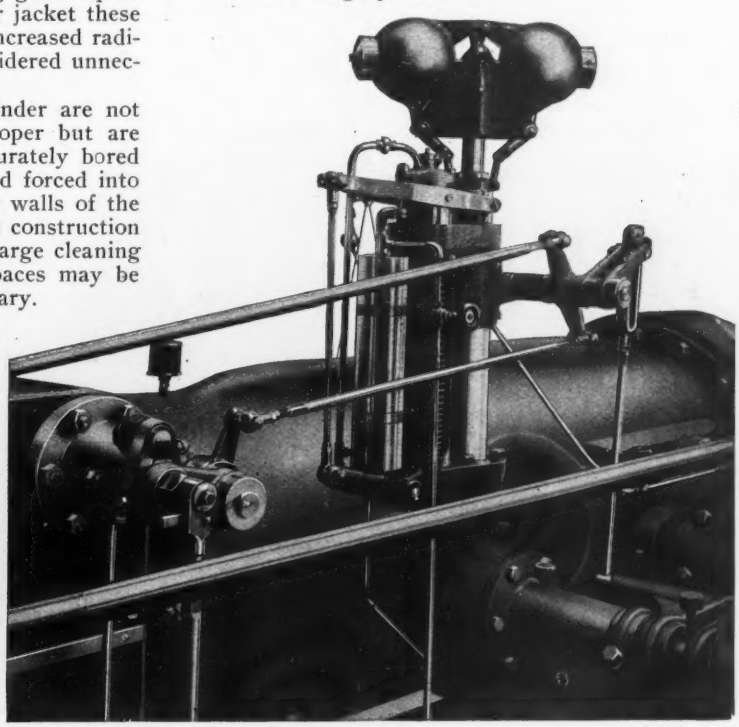


FIG. 4. ALLIS-CHALMERS PRESSURE REGULATOR AND GOVERNOR

The regulator receives its motion from a belt on the main shaft in the usual way. A floating lever is attached on one end to the yoke on the regulator spindle, in the middle to a piston actuated by the air pressure, and on the other end to the knockoff levers. As air pressure rises, the floating lever is forced down in the middle causing an earlier cutoff in the steam cylinders. At the same time the opposite end of the lever is moved to whatever position the regulator dictates. In this way the air pressure determines the position of the regulator and consequently the speed of the engine. This regulator controls the pressure so closely that less than 2 per cent variation in air pressure is sufficient to vary the speed of the compressor from full load speed to practically no speed.

Duplex Arrangement

IN Fig. 5 is shown a duplex steam, 2-stage Chicago Pneumatic air compressor, manufactured by the Chicago Pneumatic Tool Co., the principal features of which are the location of the intercooler, the method of water jacketing ,and the governing and unloading system. The intercooler provided with 2-stage compressors forms part of the compressor base, being located directly under the air cylinders, thus minimizing piping and floor space and rendering the compressor with its intercooler completely self contained. The intercooler tubes are of brass or charcoal iron, expanded into steel tube sheets. Ribs are provided in water heads and baffle plates inserted between tubes,

insuring complete circulation of both water and air. By removing bolts in the outside head the entire nest of tubes can be easily withdrawn for repairs or cleaning. Drains are provided for both air and water spaces.

Air cylinders and cylinder heads are completely water jacketed, as shown in Fig. 6, providing a thorough circulation of water with ample cooling at all points.

These air compressors are provided with a pressure regulating governor to control automatically the operation of the compressor in accordance with the demand for air, working in connection with a speed governor which regulates the speed of the compressor. Duplex and compound steam driven compressors have speed and pressure regulators only. In these classes of machines it is practicable to stop the compressor altogether when maximum receiver pressure has been reached, as there is no dead center and compressors will start under load from any position when the pressure regulator has admitted steam.

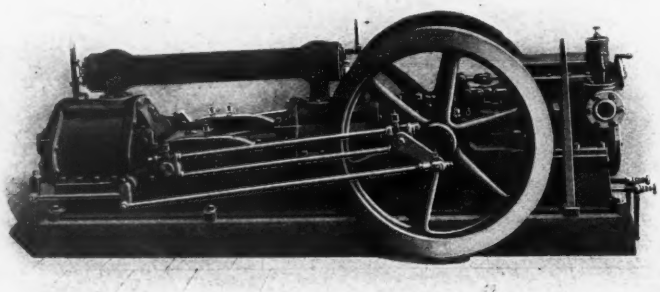


FIG. 8. NORWALK 2-STAGE STRAIGHT LINE AIR COMPRESSOR

The mechanically operated Corliss inlet valves are placed in the cylinder heads and driven by gear from eccentrics on the main shaft. These positively moved valves combine exceptionally liberal area with short ports and minimum clearances.

All air discharge valves excepting 22 and 26 in. stroke sizes, are of the poppet type, cup shaped, pressed from high grade steel and fitted with light tension spring. These valves have removable seats and guides and are readily accessible for adjustment or repairs.

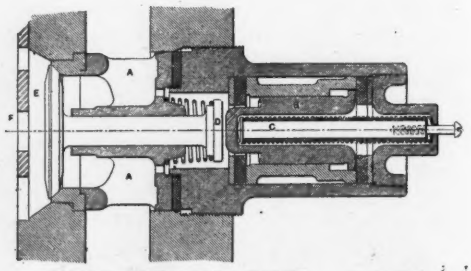


FIG. 9. THE SKIP VALVE

Compressors of 22 and 26 in. stroke have poppet discharge valves of mushroom type. They have removable guides and are easily accessible.

Straight Line Design

THERE are several characteristic features in the Norwalk air compressor which is shown in Fig. 8; it is a straight line, 2-stage compressor which employs rotary valves for both inlet and discharge, these being operated from the flywheels. Two flywheels are used, one on each side of the machine. By means of a swivel in the center of the crosshead, the work is brought exactly equal upon both connecting rods, and taking up one rod shorter than the other cannot bring any strain on one greater than on the other. Under all cicumstances of speed or adjustment, the working efforts are central and balanced.

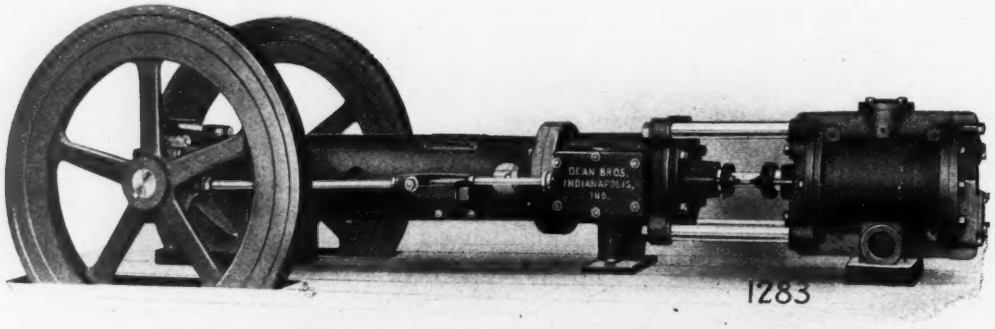


FIG. 10. DEAN BROS. DOUBLE ACTING STRAIGHT LINE AIR COMPRESSOR

Air inlet valves for these machines may be either of the poppet or mechanically operated Corliss type. When of the poppet type they are made of high grade steel, having removable seats and guides easily renewed and repaired and thoroughly guarded from entering the cylinder in case of breakage. They are placed radially in the cylinder or in heads rendering them readily accessible, insuring accurate seating, and reducing wear to a minimum.

The valve stem and head are forged in one piece, thus avoiding the use of flange-nuts or jam-nuts. The valve seat is entirely separate from the cylinder proper and may be removed, replaced or renewed whenever occasion requires.

Air is partially compressed in one cylinder, is passed through an intercooler where it is thoroughly cooled and finally is compressed to the desired degree in the second cylinder; both cylinders are surrounded by water jackets.

Another feature of the Norwalk compressor is the pressure regulator which is intended to be placed in the

pipe supplying steam to the compressor engine. This is a valve with a large globe body and is perfectly balanced. It can be moved up or down with slight effort and is not affected by the presence of the steam. An upward movement of the valve shuts off the steam and a downward movement opens the passage again. Above the valve is a small cylinder having a piston connected with the steam valve below by the stem, and at the side of the cylinder is a small spring safety valve, connected by a small pipe with the air reservoir. A small hand wheel on the top of the safety valve can be adjusted so that the valve will lift or blow at any pressure desired.

When the pressure in the air receiver reaches the fixed limit the safety valve will begin to allow air to pass it to escape. The air passes into the small cylinder beneath the piston and, if no escape were provided, would drive the piston to the top of the cylinder. To regulate this action a fine slot is cut in the side of the small cylinder, so that, when the piston rises it uncovers this slot, thus furnishing an escape for the air which is passing the safety valve. If only a little air passes the valve, a small part of the slot will accommodate it and the piston will take a low position. With more air escaping, the piston will rise higher and uncover more of the slot, thus providing a larger opening for air exit. Any degree of regulation is thereby obtained with little difference of pressure.

When this regulator is applied to compressors having a single steam cylinder it is possible for the valve to be carried so high as to shut off all the steam and stop the engine on the center. This would be objectionable, therefore there is placed on top of the small cylinder a screw top which can be set to prevent the closing of the steam valve more than is sufficient to run the engine at the lowest speed at which it will pass the centers.

For unloading the compressors, the Corliss air valve is attached to the stem by a hook or latch similar to the arrangement on the Corliss steam engine. When no more air is wanted, the air pressure automatically trips the latch and the valve remains wide open, allowing the air to flow in and out unobstructed at atmospheric pressure, thus relieving the machine of all load.

Another device sometimes attached to Norwalk 2-stage compressors is known as the skip valve, an arrangement by which the compressor can furnish 2 different pressures and maintain them constantly. These valves are used as inlet valves to the second cylinder. The arrangement is such that if the pressure in the intercooler falls below a certain predetermined point, then the skip valve will remain open and thereby the second cylinder rejects its supply of air to the intercooler. Above each inlet valve is a small piston or plunger having a spring over it which forces the plunger down onto the stem of the valve and keeps it open. If, however, the air pressure beneath the plunger is of the amount for which the spring is adjusted, then the plunger compresses the spring and moves back away from the valve and allows it to act in the normal manner.

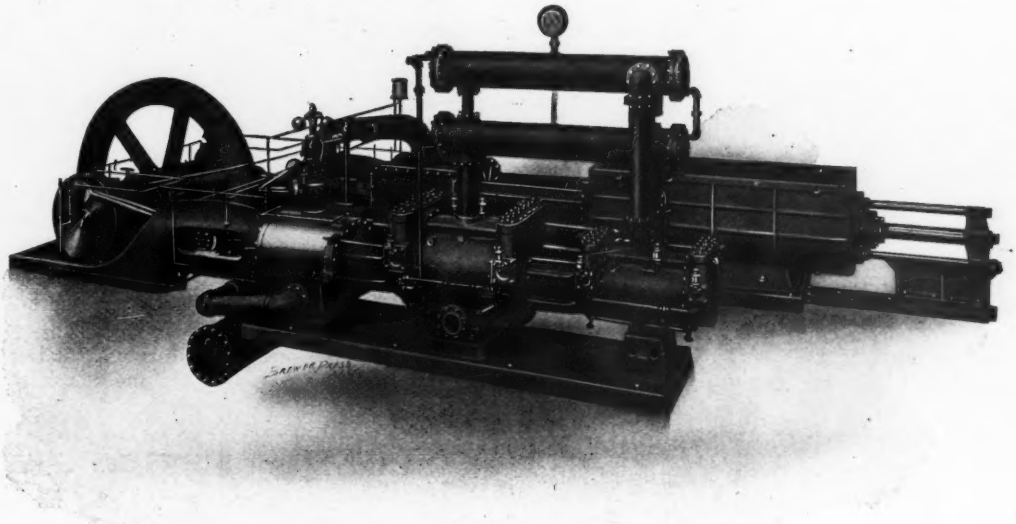


FIG. 11. CROSS COMPOUND 4 STAGE HIGH-PRESSURE COMPRESSOR

A type of single cylinder, double acting, air compressor made by Dean Brothers Steam Pump Works, of Indianapolis, is shown in Fig. 10. This is operated by steam and is suitable for working pressures up to 100 lb. The flywheels are heavy and of ample diameter to reduce jerking and give a steady load. The air cylinder is water jacketed and made with phosphor bronze valves and seats both inlet and outlet valves being of the poppet type. Clearance is reduced to the least possible amount by the proper location of the valves. It is provided with governor for automatically regulating the air pressure.

Compressors for Extremely High Pressures

THE construction of the Liadlaw-Dunn-Gordon high-pressure compressors for operating against 500 to 5000-lb. pressure in from 3 to 5 stages, is unusual in the design of the high-pressure cylinders. Compression in the last 2 stages of these machines is effected in single acting cylinders of the simplest possible construction, with outside packed plungers, the cylinders being placed end to end in an open box filled with water. This construction leads to the immediate detection of any leakage either in stuffing boxes or joints, such leakage being immediately betrayed by air bubbling up through the open water box.

Compressors of this type have been extensively used for pneumatic locomotive charging in mines ser-

vice, for the liquifying of carbonic acid gas and for the liquifying of air. The extreme simplicity of the high-pressure construction eliminates the most frequent troubles accompanying this class of work, namely, piston and jacket leakage.

Figure 11 illustrates a compressor of this type which compresses to 1000 lb. pressure in 4 stages. It is equipped with Meyer valve gear on the high-pressure steam cylinder and Cincinnati steam gear on the low-pressure and Cincinnati air valve gear on the first intermediate and low-pressure air cylinders.

Vertical Compressor

AS an example of vertical compressors, that shown in Fig. 12 is notable and is made by The American Well Works. It is of the vertical, cross-compound, steam-driven, 2-stage type. The air cylinders are completely water jacketed, barrel and covers. The air valves are of poppet type seating on removable seats, the inlet valves working vertically, seat more perfectly after long use. This type of compressor requires less space than necessary for a horizontal compressor and the pistons working vertically have no wear in the cylinders or packing boxes caused by their weight. Compressors of the horizontal type are also made by this company.

Gasoline Engine Driven Compressor

USE of internal combustion engines has increased greatly during the past few years, and to take advantage of the high economy of these engines in the compression of air, a combined unit has been developed by Fairbanks-Morse & Co., this is shown in Fig. 13. It is a gasoline engine connected through

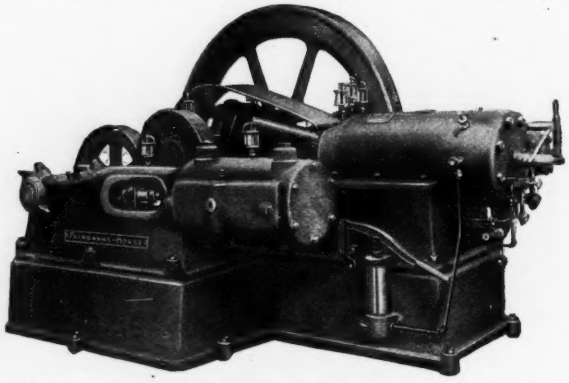


FIG. 13. FAIRBANKS-MORSE GASOLINE ENGINE DRIVEN COMPRESSOR

Since it is necessary to keep the engine running at or near normal speed regardless of the load an unloading device is used on these compressors. The unloading valve body contains a bronze piston loaded with an adjustably weighted lever. When the desired maximum pressure is obtained the unloading device allows air to pass through tubes to brass pistons placed directly beneath the suction valves, these pistons then raise the suction valves and allow atmospheric air to circulate between both ends of the cylinder.

Belt-Driven Air Compressors

COMING now to the subject of belt-driven air compressors, we find them in much smaller capacities and equipped with flywheels and crank shaft. As a general rule, those built horizontally are of the double-acting type while the vertical type of belt driven air compressors are frequently single-acting.

In Fig. 14 is shown a belt-driven air compressor made by the Nagle Corliss Engine Works, which also builds steam driven compressors in all sizes, which has a number of distinctive features. The inlet valves are placed radially and are made with a hollow stem and held to their seats by a spring. This construction is very light and does not appreciably reduce the pressure of the air during the intake stroke. Likewise the discharge valve is made with a hollow stem and light springs, and is perfectly balanced, making it easily raised from the seat when the pressure within the cylinder reaches the pressure of the receiver.

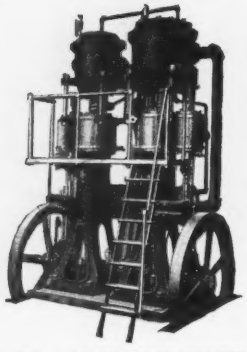


FIG. 12. AMERICAN VERTICAL DUPLEX AIR COMPRESSOR

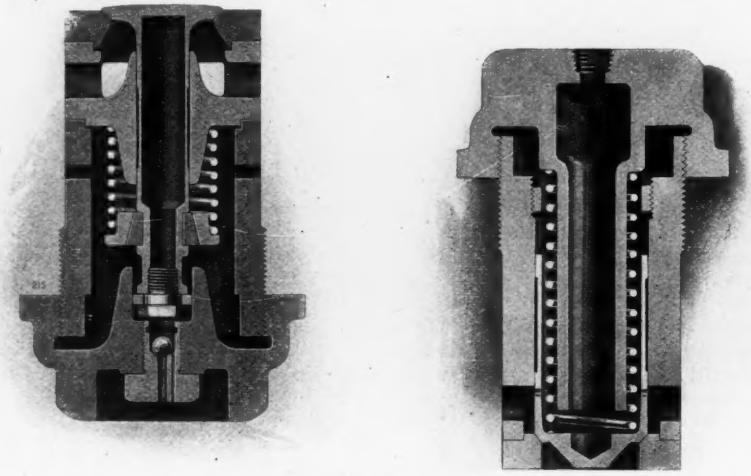


FIG. 15. INLET AND DISCHARGE VALVES OF NAGLE COMPRESSOR

gears to a double acting air compressor, all mounted on a single base.

Both inlet and discharge valves of this compressor are of the poppet type. The cylinder is water jacketed with water passages so arranged that the water passes first around the valves and through the heads where the heat due to compression is highest and thence around the cylinder barrel.

Beneath each poppet valve there is a bar or grid placed to preclude the possibility of an accident if, for any reason, a valve should become loose which might otherwise project or drop into the cylinder. All poppet valves seat in removable bronze cases which are flanged and held in position by cast-iron plugs screwed into the heads.

Another feature is the method of water jacketing and means for draining the jacket. It will be seen from Fig. 14 that water enters the lower side of the cylinder head from a common pipe; passing up through the cylinder heads, the water goes through a system of piping to the lower side ot the cylinder barrel and discharges from the upper side into the drain connection.

It will be noted that by the system ot valves used it is an easy matter to regulate the amount of water flowing to each cylinder head and this can be varied to suit the condition of the temperature ot the cylinder. It will also be noted that the connection to the crank end of the cylinder barrel is through a tee, the lower side of which is connected directly to the common inlet pipe, through a valve. By this arrangement, to drain the water jacket, it is only necessary to close the valve admitting water to the cylinders, open the valve to the drain, also the valve between the crank end of the barel jacket and the common supply pipe, and all the water will be drained from the cylinder heads and the barrel jacket.

For pressures up to 30 lb. and continuous service, the small belt-driven air compressor shown in Fig. 16, which is made by the Goulds Mfg. Co., has several advantages. It is especially adapted for use in connection with dry sprinkler systems in mills, factories,

In Fig. 17 is shown a self-contained motor-driven air compressor, employing 2 cylinders of the single acting type. This compressor is made by the National Brake & Electric Co., and is known as National type "H" compressor. It is equipped with a direct current motor of the enclosed type and built for intermittent

FIG. 16. GOULDS POWER AIR COMPRESSOR

service with equal intervals of work and rest, no one running period to exceed 30 minutes. For this reason the cylinder heads are not water jacketed and no water is required in the operation of this compressor. The cylinders are cast integral with the crank case and are made of fine grained cast iron. The cover of the

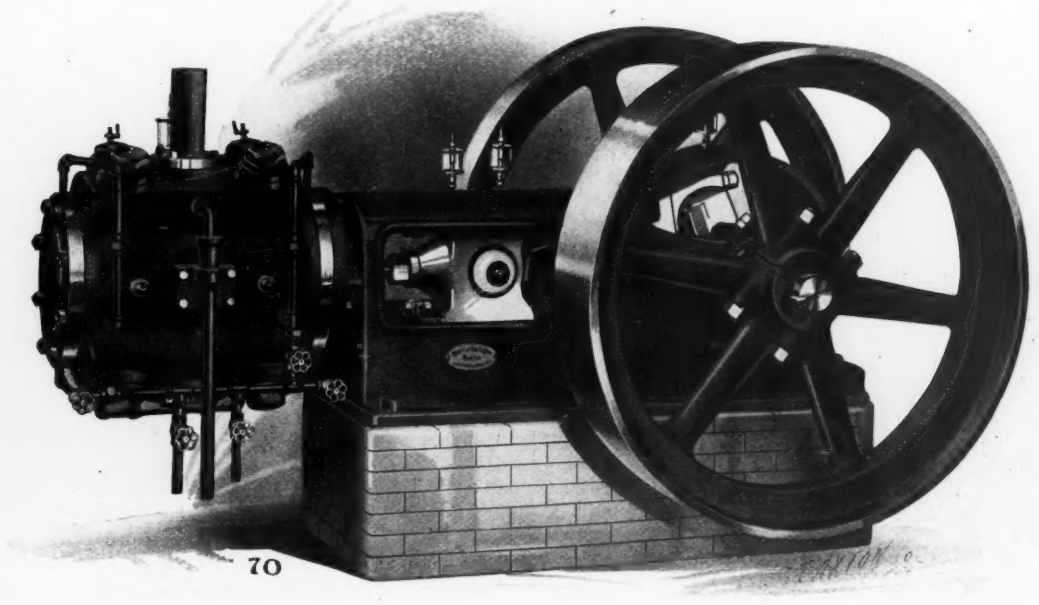


FIG. 14. NAGLE BELT-DRIVEN AIR COMPRESSOR

warehouses, etc., compressing air into receivers for agitating liquors or for any service where a low air pressure is required. The cylinder is provided with radiating air cooling rings, and is single acting. The plunger is metal ring packed and the valves are metal of an improved pattern. A tight and loose pulley is one the crank shaft, the tight pulley having an extra heavy rim acting as a flywheel.

Electrically Driven Air Compressors

MOTOR driven air compressors were first developed for air brakes on street cars and the like, but have become more generally used particularly where compressed air is used in small quantities and intermittently.

crank case and the motor base is so arranged that an air space is provided between the motor and compressor, admitting air to circulate freely between the two, which serves to prevent the motor from becoming over-heated.

A one-piece valve head made of cast iron is bolted to the end of the cylinders and contains chambers to receive suction and discharge valves associated with each cylinder. The suction valves have 2 openings, one on each side of the valve head. Either or both can be used to admit air. The discharge valves have an opening in common situated in the center of the valve head.

The valves, 4 in number, are cup shaped and machined from solid bars of steel. They are guided by

vertical plugs extending into them and are returned to their seats by their own weight.

Control of the air pressure maintained by this machane can be automatically effected by means of a

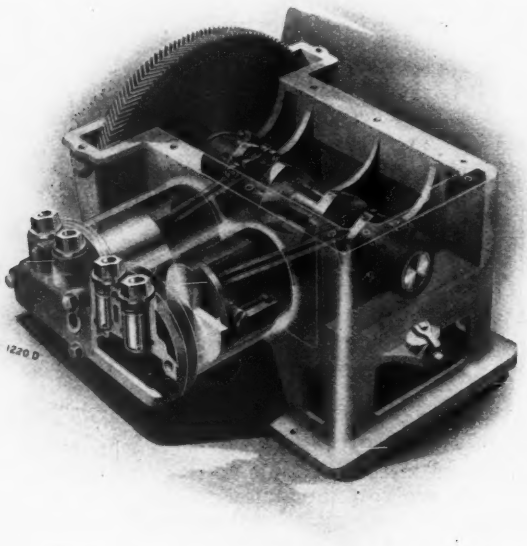


FIG. 17. PHANTOM VIEW OF A NATIONAL COMPRESSOR

governor, which starts and stops the motor at predetermined minimum and maximum pressures. Were the load to be taken off the compressor by the unloading of the suction valve, the speed would become excessive and endanger the motor, since it is series wound. To run at constant speed, regardless of the compressor load, would require that the motor be of shunt wound construction. This, however, is impractical for intermittent service, owing to the design of the motor, since a shunt motor requires an automatic rheostat, which in a small size compressor involves undue complications, which increase the cost.

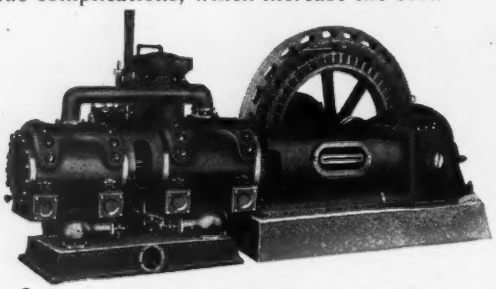


FIG. 18. BURY VARIABLE VOLUME AIR COMPRESSOR WITH SYNCHRONOUS MOTOR DRIVE

A new construction in air compressors is the new Bury Variable Volume air compressor, which, as shown in Fig. 18, is driven by a synchronous motor mounted directly on the crank shaft of the compressor. This compressor is equipped with the Bury pneumatic force feed oiling system.

While in the illustration the driver is a cynchronous motor, these compressors may be built to meet any requirements with belt wheel and driven from motor by belt.

The air valves used are of the Corliss straight shot intake and cushioned poppet discharge valves designed to operate with minimum of shock and wear, preventing all blow-back. They are self contained, easily removed and replaced, the valves seating upon their own guides with no wear on the cylinder walls. The cards taken from Bury machines equipped with these valves may be compared favorably with the best Corliss steam engine cards.

The particular machine shown in the illustration is of special value where variable volume of air is required, as it automatically supplies any volume of air needed without changing the speed of the machine; it provides for the lowest possible cost of operation, especially where electrical companies charge for their current, based on the daily peak load of machines while in operation. It is possible to accomplish high economy with this machine along this line and materially lower the cost of the power to operate the compressor to meet variable conditions. This machine is especially adapted for large units in mining and other fields where power driven and direct electric motor driven compressors are in use.

Centrifugal Compressors

OWING to the high speeds which are attainable and consequent smaller machine and less space required, rotating machines of all kinds are supplanting reciprocating types in a great many instances. In line with this change in practice the centrifugal compressor is becoming more common and its possibilities as well as its limitations are better understood.

At the present time the compressors are used most extensively as blowers in blast furnaces, foundry cupolas, steel converters, etc., where a great amount of air is required at comparatively low pressure. In construction centrifugal compressors are extremely

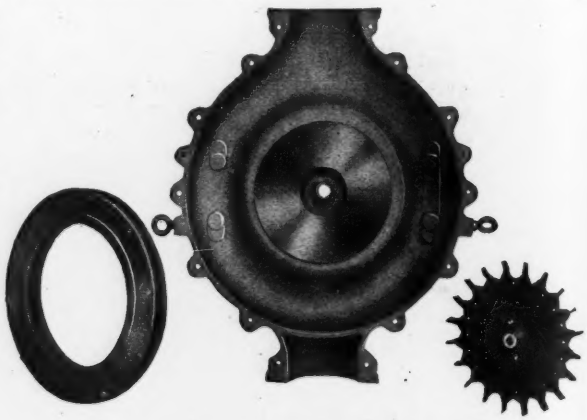


FIG. 19. PARTS OF CENTRIFUGAL COMPRESSOR

simple, consisting of an impeller with properly shaped vanes mounted upon a shaft. The impeller runs in a casing provided with inlet and outlet openings of suitable dimensions and fitted with discharge vanes which aid in changing the velocity energy of the air leaving the impeller into pressure energy. The pressure obtainable by a single impeller is small, but by the use of several of these in series, pressures of several atmospheres may be obtained.

The most common method of driving centrifugal compressors is with a steam turbine, the revolving parts of the turbine and the compressor being mounted upon the same shaft. This arrangement makes a compact and comparatively inexpensive unit which can easily be designed to give either constant pressure or constant volume of discharge. The parts of one type of centrifugal compressor made by the General Electric Co. are shown in Fig. 19.

REGULATION OF POWER COMPRESSORS

By Lucius I. Wightman

SINCE the power driven compressor is almost always a constant speed machine, the methods of regulation and governing steam-driven machines evidently cannot here be applied. Constant speed means constant piston displacement; and the problem of delivering a variable volume of air with constant piston displacement becomes one of making a portion of that displacement noneffective in the compression and delivery of air. Only the fundamental principles of several methods of accomplishing this will here be discussed.

The first method is really one of unloading, rather than of regulating. A pressure controlled mechanism is arranged so that when pressure exceeds normal due to excess of delivered volume over demand, a communication is opened between the 2 sides of the compressing piston. Usually this is accomplished by opening and holding open one or several of the discharge valves at both ends of the cylinder, the air then simply sweeping back and forth from one side of the piston to the other through the open valves and the air discharge passage. When normal pressure is restored, the valves are automatically closed, and compression and delivery are resumed.

Evidently this is practically a total unloading of the machine for a longer or shorter period—a sudden release from load and a sudden resumption of load.

Another method provides, by means of a pressure operated device, for the partial or total closing of the compressor intake under reduced load. To avoid the dangers attendant upon such an operation acting suddenly, these devices are provided with some damping mechanism so that they are compelled to operate slowly, making the release or resumption of the load gradual.

Cutting down of the air intake results in a rarification of the air entering the cylinder, and a greater range between initial and discharge pressures, with a corresponding increase in the range of temperatures. This method of regulation, therefore, is not suitable for very great load variations; nor is it recommended for such conditions by the builders responsible for it.

The third method is very similar to the first, except that here the inlet valves, instead of the discharge valves, are held open when the machine is unloaded, the piston thus simply drawing in and forcing out air at atmospheric pressure. It is open to the same criticism (though in somewhat less degree) as the first method, namely, undue shock and strain on release and resumption of load.

The fourth method uses a pressure-controlled valve on the compressor discharge of a single stage machine, combining also the functions of a check valve to limit the escape of air from the receiver or air line. Excessive pressure blows the discharge to atmosphere, instead of into the line. This arrangement is also used on 2-stage machines by placing it on the low-pressure discharge to the intercooler. Then, when the governor valve is opened by excess pressure, the low-pressure cylinder discharges to atmosphere, and the high-pressure cylinder acts simply as a low-pressure cylinder with intake at atmospheric pressure.

This device is more of a relief valve than an unloader, for the piston must continue to compress to a pressure which will open the discharge valves; and this volume of compressed air, with its power equivalent, is wasted.

Yet another method of regulation provides auxiliary clearance spaces, or pockets, at each end of the cylinder, which are successively "cut in" as load diminishes. The excess air is simply compressed into these clearance spaces and expanded on the back stroke. The capacity of the cylinder is reduced without any appreciable waste of power, for the energy used in compressing the clearance air is given back by its expansion.

On power-driven compressors with Corliss intake valves, several different methods of unloading or regulating are used.

By one method, the Corliss valve is held open for the full admission stroke, and also for a part of the compression stroke, this latter portion being determined by the degree of unloading called for.

Evidently this is practically equivalent to a shortening of the stroke of the compressor.

By another method the Corliss intake valve is opened full at beginning of admission, but closes later in the admission stroke. The air admitted to that point is expanded or rarified for the remainder of the compression stroke, and then compressed, the volume of compressed air delivered being of course reduced. This arrangement is productive of an excessive temperature range in the cylinder. Still a third method opens and holds open the intake valves at the end of the cylinder, or at opposite ends in duplex machines. The effect of this is to make ineffective one out of every 2 strokes. If still further unloading is necessary, the intake valves at the other end of the cylinder or cylinders are opened and held open.

The 3 arrangements just outlined all operate by a pressure-controlled mechanism which actuates some form of trip or release on the Corliss air valve gear, somewhat similar to the release mechanism of the Corliss steam valve for varying the cutoff.

Three things are to be avoided in the successful unloader or regulator for power-driven machines; first, a sudden release or resumption of load, throwing heavy strains on the machine; second, undue rarification of the intake air, resulting in a wide range of cylinder pressures and temperatures; third, the blowing off of compressed air to the atmosphere with a waste of power.

It is usually desirable to start a power-driven compressor with no load, throwing on the load gradually after normal speed has been reached. This is in fact essential in machines driven by electric motors, for the heavy inrush of current in starting under load is dangerous, particularly where power is taken from a transmission circuit supplying other motors.

Evidently almost any of the unloading devices noted in the previous section can be used for this purpose if properly arranged for manipulation. The usual form, however, is simply a bypass valve to atmosphere on the line close to the compressor, protected by a check-valve between it and the receiver to prevent the return of air from the line when the starting unloader valve is open. This check valve is essential where several compressors serve one line, permitting cutting in or out any machine without unloading the others. This bypass valve is opened on starting, when the compressor simply compresses to a pressure sufficient to open its discharge valves, the air escaping to atmosphere. When normal speed is reached the bypass or unloading valve is gradually closed and load resumed. On 2 stage machines, an unloader valve should be provided on the low-pressure discharge to the intercooler, as well as on the high-pressure discharge to the line. In the latter case, both cylinders operate momentarily as low-pressure cylinders.

THE AIR LIFT

Principles Involved, Applications, Pipe Proportions, Pressures and Air Required

By Frank Richards

ONE of the most important, and now also among the most extensive and most rapidly extending employments of compressed air is in the so called "air lift," used for the raising of water and other liquids. This name is not correctly suggestive of the characteristics of the device, but it seems to be quite firmly fixed and no one seems to be able to supplant it with anything better.

The water-works of many towns and cities in the United States and elsewhere are entirely dependent upon the air lift, and its use for the obtaining of water from its natural subterranean sources is rapidly extending throughout the civilized world. It is used largely for the pumping of oil wells, for the unwatering of mines, and it handles semi-liquids, or liquids carrying a heavy burden of comminuted solid matter, with the same facility as clear water, making the water thus in many cases the cheapest conveyor available.

The adoption of the air lift for any specific service is seldom determined upon by considerations of power economy alone. It has its special adaptions to some exacting conditions, and it may be said to hold its own and to be continually extending its holdings by the fact that it can do work to which no other devices can be applied. The wide range of its employments, and its continuance in them is the best possible evidence that after all it pays. It is also free for anyone to employ it, as there can be no monopoly of the principle involved.

It is not necessary to make any mystery of the operation of the air lift, and no one has any privilege to pose as an exclusive repository of special information concerning it, although in the practical applications of it experience counts for more, and is more absolutely necessary than in almost any other field.

Principle of Operation

THE essential principle involved seems to be very simple and to be easy of explanation. Say that we have an open well, or in fact any body of water so that it be deep enough and regardless of its volume or what may enclose it, a pond or lake or river being as good for our purpose as a well of whatever dimensions; and say that in this water is suspended or fixed a vertical pipe with open ends, the lower end extending a considerable distance below the surface of the water, the water being thus perfectly free to enter the pipe. Under the conditions, the water will rise to the same height inside the pipe as it is outside, and when the water levels coincide there will be nothing operative to cause any movement of the water either upward or downward.

If we wish to induce the water inside the pipe to rise higher than the water outside the pipe it can be done by reducing the weight, or more correctly, the specific gravity of the column of water as a whole contained within the pipe, and then the greater relative weight of the water outside the pipe will act to force the lighter column of water upward. The simplest way in the world to lighten the column of water in the pipe would seem to be to mix air with it, and this the so called "air lift" does, and it is practically all that it does, while gravity does the rest.

Say that, with our pipe standing in the water as above assumed, and with the water standing at the same height within it as outside, a compressed air pipe considerably smaller than the other is run down alongside with its lower end turned up and reaching a little distance up into the large pipe, as in Fig. 1. In the placing of this air pipe it may be supposed that the water has entered it and has risen in it to the normal water level, if there has been no confined or compressed air in the pipe to oppose it. If now compressed air is turned on to the small pipe with a pressure sufficient to drive the water down to the lowest point in the bend of the pipe, the pressure required being determined by the height of the water surrounding the pipe and this pressure, 1 lb. for each 2 ft. (speaking loosely) of water depth, being the greatest pressure that will be called for in the operating of this particular lift, then as soon as the bend in the pipe is passed the air will escape upwards out of the air pipe and will diffuse itself through the column of water above.

We must not go too fast here. The air "lift" has not yet begun its lifting. The diffusion of the air through the column of water elongates the column of water upward but does not yet lighten it as a whole. The air might go on mixing with and diluting the water and gradually working its way up through it and finally, if the pipe was long enough, the air would escape at the top of the column as fast as it was admitted at the bottom, but still there would be no "lifting" of the water by this operation alone. This gradual working of its way up through the water which the air thus does in the stationary column goes on also, but not so rapidly, when the column is moving and the lift is in full operation, thus constituting the "slippage" which seems to be one of the unavoidable sources of loss in the air lift.

As a matter of fact in the air lift the air does not work its way up through a column of water of unlimited length and escape out of the water at the top, leaving the water inert. Before this height is reached the water pipe ends and there is a continuous discharge of its contents. This discharge of the upper portion of mingled water and air at once reduces the weight of the column and then it begins to be pushed upward by the heavier solid water which is now able to force its way in at the lower end. The escape or discharge at the top makes the column continually lighter than is required to balance and entirely resist the in-pressing water below, so that the solid water continues to flow in, and then the entire column is kept rising and flowing off at the top, as long as the supply of compressed air is sufficient to maintain this condition of unbalanced pressure; and there we have the air lift complete. It is ultimately worked as we see entirely by the force of gravity.

It will be better to finish with the air and its career in the water before considering the action of the resulting unbalanced pressures. The levitation function of the air being understood, it will be evident that it must be desirable to have it mixed as intimately as possible with all the water in the column, so that here ingenuity and invention may play an important part in providing means for scattering the air and mixing it at the beginning all through all the water. If such scattering and intimate mixing of the air with the water does not occur at the instant of its discharge

from the air pipe no such result can be possible later. It is to be assumed that the air will be distributed through the water in bubbles, large or small, and it is better that they should be as small and as numerous and as nearly as possible at uniform distances apart rather than to have them fewer and larger and irregularly distributed.

The originally propounded theory of layers of air alternating with pistons of water in the pipe represents an absurd impossibility. Whatever the number and size of the air bubbles at the beginning they will always be merging together to form fewer and larger ones. Whether the aerated column be stationary, as first assumed, or moving upward with the lift in full operation, the levity of the column which the air is employed to produce, will be determined by the amount of air actually distributed through it during the period of its upward passage through the pipe. If some of the air escapes by working up through the column, instead of moving with it, it represents power lost, and this loss will be greater with large bubbles than with small, because they will always float up through the water at the greater speed.

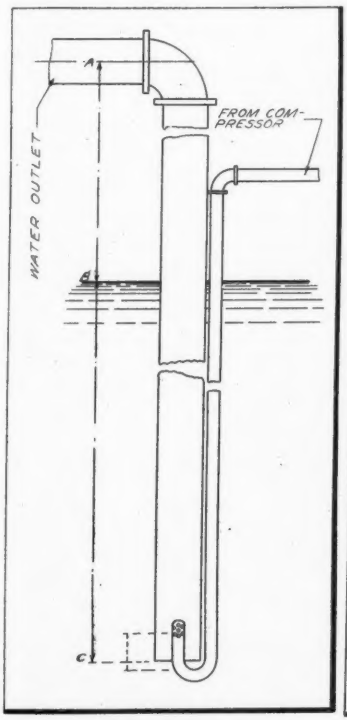


FIG. 1. AIR LIFT WELL ARRAGEMENT

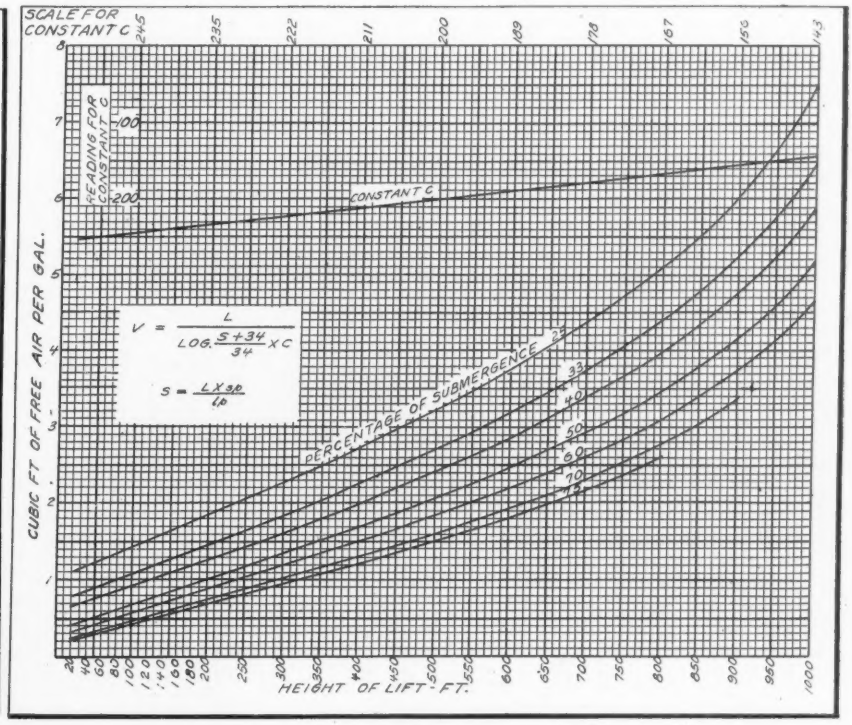


FIG. 2. FREE AIR REQUIRED FOR AIR LIFT

Air Used Isothermally

IN its operation the air lift uses the air expansively and gets the benefit of the expansion. When the lift is in full operation and the air and water mixture is flowing at a uniform speed through the discharge pipe there will be at any instant a given quantity of water and the equivalent of a given volume of free air. The air actually will not be either free air nor air at the full working pressure. When it is first discharged from the air pipe and mingles with the water it has already lost a small portion of its pressure, and as it rises with the column it will expand as the pressure due to the depth decreases, and it will be discharged with the water at a pressure little above that of free air. As the value of the air in the column is in the quantity of water it displaces this displacement will be greater per volume of free air at the top of the column than it will be anywhere below it. As the air is so intimately mixed with the water it must be assumed to take the temperature of the water, or its expansion may be said to be practically isothermal, which is as profitable to the user of the air when expanding as the absence of this condition is unprofitable when the air is being compressed.

Compressed air in the air lift, it has been seen, does not push or force the column of water upward after the lightening of the column, the latter being its only function, and the flow upward is caused by the unbalanced weight of the solid water outside and below the pipe. This suggests at once the necessity of maintaining a sufficient preponderance of pressure from the inrushing water, and this is only secured by the submergence of the pipe or its extention to a sufficient depth below the surface of the water. The height of the lift is the principal factor in determining the submergence required, the invariable condition being that the higher the lift the greater shall be the actual submergence.

As to this particular mistakes are often made. In planning an air lift for a bored and tubed well wherein the water does not rise to the surface but stands constantly at a certain distance below the surface, it is comparatively easy to compute approximately the submergence which should be adapted for delivering the water at a given height, experience rather than theory dictating the figures; but if when the pumping begins the height of the water in the well falls any considerable distance, as it often does, then the proportionate and the actual submergence may be quite inadequate. The submergence will be reduced as many feet as the surface of the water supply falls, and the lift will be increased an equal distance, a double-acting

cause of inefficiency. In many cases where a new air lift is installed provision is made for lengthening or shortening the pipes to get the best submergence according to the developed working conditions which could not have been anticipated.

With a given submergence the lift may be more or less, within wide limits, and the lift will still work, but there is for each case an approximate ratio of submergence to lift which gives the best results, both as to the volume of liquid raised and also as to the air cost, or power cost, of raising it. With a fixed submergence, whether the lift be proportionately small or whether it be as high as possible, the air pressure required will be the same, but while the pressure is thus determined by the submergence the actual volume of air per unit of time, and also the volume of water raised will be influenced and determined by other conditions, especially by the actual volume of air supplied and the resultant rate of flow of the water.

Proportions of Air Lift Well

IN computations upon the air lift the submergences are stated in percentages. The submergence percentage is that portion of the whole length of the discharge pipe which is submerged, the remaining percentage constituting the lift. Thus with a lift of 100 ft., if the submergence is 60 per cent, the lift, or 100 ft. will be 40 per cent. The 60 per cent, the submergence, will be 150 ft. and the total vertical length of the water or discharge pipe will be 100+150=250 ft. In Fig. 1 A B is the lift and B C is the submergence, both being stated in percentages of the total length A C.

Attention is now directed to the chart or diagram, Fig. 2, from which may be readily determined the volume of free air required with different percentages of submergence to raise 1 gal. of water to different heights from 20 ft. to 1000 ft. The data embodied in this diagram are practically the same, except in one particular, as the figures of a table given to the public 2 or 3 yr. ago by E. A. Rix of San Francisco, who has done much in various ways for general compressed air practice, the table having been computed by Geo. H. Reichard of the same city.

The formula by which the table spoken of was computed is as follows:

$$V = \frac{L}{\text{Log.} \frac{S + 34}{34} \times C}$$

Here V is the volume of free air in cubic feet, this being in this case the actual piston displacement of the compressor.

L is the lift in feet.

C is a constant, 234, unchanged throughout the computing of the table.

S is the actual submergence in feet, which is obtained as follows:

$$S = \frac{L \times sp}{lp}$$

sp being the submergence percentage and lp the lift percentage.

Say that the lift is 100 ft. and the submergence 60 per cent, then:

$$S = \frac{100 \times 60}{100 - 60} = 150$$

Using figures now in the original formula we have:

$$V = \frac{100}{\text{Log.} \frac{150 + 34}{34} \times 234} = 0.584 \text{ cu. ft.}$$

For the air pressure required for any lift and at any percentage of submergence it is convenient to divide the actual submergence in feet by 2 to get the gage pressure in pounds. This gives enough pressure in excess of that due to the water head to allow for the pipe-friction and other losses.

The one particular in which the computations for our diagram differed from these for the Rix table spoken of was in the constant C. This, as indicated by the line in the upper part of the diagram, instead of remaining the same, 234, all through, was made to decrease gradually as the lift increased. Thus for a lift of 200 ft. our constant is 235, practically the same as that used by Mr. Reichard, but for 100 ft. lift it is 245, for 500 ft. it is 200, and so on. The result of this is to increase more rapidly the free air per gallon as the lift increases, which seems to agree better with observed results.

The line in the diagram for constant C follows very closely the figures given by H. T. Abrams, air lift expert of the Ingersoll-Rand Company, in a lecture at Columbia University.

The most striking thing observable in an examination of this diagram is that the volume of free air required per gallon of water raised constantly decreases as the submergence increases. Thus at 25 per cent submergence and 200 ft. lift the free air required per gallon is 1.83 cu. ft. while for the same lift and 60 per cent submergence the free air is 0.88 cu. ft., or less than one-half. In the first case, however, the air pressure required is about 17 lb. gage, while in the other case the pressure would be 75 lb., and the mean effective pressure required for the compression of the air (adiabatic) to 17 lb. would be about 13 lb., while for compressing to 75 lb. the mean effective would be 35 lb. Then comparing $1.83 \times 13 = 23.79$ with $0.88 \times 35 = 30.80$ it appears at once that the apparent cheapness is nullified or reversed, and other considerations determine what submergence is best.

The air lift is intended for steady work and not for occasional and frequently intermittent service. It is not to be stopped and started at any odd time like a common reciprocating lifting pump. Its efficiency is largely influenced by the correct adaptation, or otherwise, of the sizes of air pipe and discharge pipe to each other and to the rate of air delivery, the latter being entirely controllable, while the inflow of the water adjusts itself to the conditions provided. Nothing is thought of here but the relations of discharge pipe and air pipe to each other, it being assumed temporarily that the water is free to flow into the bottom of the discharge pipe as the "air lift" takes it away. The speed of this voluntary (as we may call it) and uncoercible inflow of the water really determines the best working speed, and also, within certain limits, the possible working speed of the air lift. As might naturally be supposed the rates of flow in the pipes and the corresponding actual deliveries of water will be more rapid for the low lifts and small actual submergence than for the high lifts and deep submergence, the greater length of pipe causing the greater retarding friction.

While from what has been written above it would seem that almost anyone might install and operate an air lift, there is probably no application of compressed

air in which experience counts for so much, and it is recommended that in all cases a competent expert be consulted or employed. In this view of the case it does not seem worth while to lengthen this article by the insertion of tables of pipe capacities and other working data, as these may be obtained from builders of air compressors and others in touch with the business.

CAPE MAY CITY AIR LIFT WELL

By Frank C. B. Spence

IF the readers will look up the map of New Jersey they will see that Cape May City is situated on the extreme southern point of New Jersey. That it is about 18 miles distant from the mainland. In other words, the map is about like a man's closed hand with the index finger extended and the point of the finger represents Cape May City. The Atlantic Ocean on the east, the Deleware Bay on the west, the nearest stream of fresh water is about 30 miles distant. The only way we can obtain water is to go down into mother earth. For a number of years the city was supplied with water obtained from open or dug wells. Owing to the increase in population, the demand became so great that in 1902 it was determined to drive tubular wells, but to ascertain to a certainty the depth of the water stratum an experimental well was driven. At 130 ft. a good supply was obtained; at 522 ft. a stratum of rock was met, this was 15 ft. in thickness; at 575 ft. a fine supply of water was obtained. The driving was continued to 1313 ft. 6 in. From 600 ft. to the bottom of the well

FIG. 1. CAPE MAY CITY AIR LIFT WELL DURING PRELIMINARY TEST

there was but little water. Several strata of rock were driven through ranging from 2 ft. to 15 ft. The last of the sands obtained from the well was Greensand or marl.

The well was then drawn to the 575 ft. level. From this depth there was obtained 350 gallons a minute. The tidal movement in this well is 4¾ in. The water flowed within 9 ft. of the surface. The well is 8 in. 430 ft. reduced to 6 in. to pass through the stratum of rock at 522 ft. and to the 6-in. pipe is fitted a Cook strainer.

In 1911 it was decided to install the Harris Air Pump System in the deep well and 2 others if satisfactory after tests. Tests were made on the deep well as follows:

February 28, 1911 flow obtained, 840 gal. per min.
March 1, 1911, flow obtained, 840 gal. per min.
March 18, 1911, flow obtained, 900 gal. per min.

The photo, Fig. 1, was taken March 18. When the tests were made the water level in the well was 11 ft. The air pump used was a Harris special air pump, pump submergence 155 ft., air line 1¼ pipe, air supplied by an old style Ingersoll compressor, air pressure at receiver 51 lb., water in well pulled down to 50 ft., free air required 285 cu. ft.

From the fine results obtained from this well a contract was awarded to L. T. Edwards & Co., of Philadelphia, Pa., eastern representatives of the Harris Air Pump Co., to instal the air pump system in the deep well and 2 other wells that had been drilled to the 130-ft. level.

The work of installation was completed June 23, 1911, and the wells placed in service the same day. The deep well yielding 1000 gallons per min., the other 2 390 and 400 respectively. From these wells we pumped by direct suction:

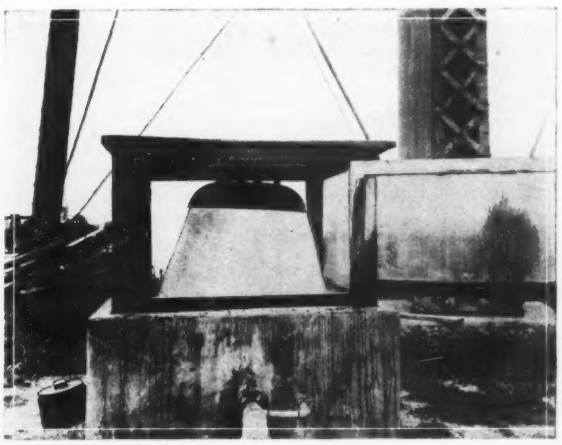


FIG. 2. FINAL TEST OF CAPE MAY CITY AIR LIFT WELLS

Deep well 350 per min.
No. 1 well 200 per min.
No. 8 well 174 per min.

Under the air system the wells yield as follows:

Deep well 1000 gal. per min.
No. 1 well 400 gal. per min.
No. 8 well 390 gal. per min.

In other words we have increased the flow from these wells 1066 gal. per min.

The wells were tested and photo Fig. 2, was taken Sept. 23, the yield being the same as in June and all other conditions being the same.

The air is furnished by an Ingersoll-Rand Compressor, Class N.F. 1. Size: steam 12 by 12 in., air 16¼ by 12 in., with all 3 wells in operation the air pressure is 51 lb., speed of compressor 176 r.p.m. I think we have wells, the flow of which is seldom equaled.

The works consist of 2 100-hp. return-tubular boilers, one 100-hp. locomotive type boiler, this is at the auxiliary station, 1 duplex compound Worthington pump, size 14 and 20 by 14½ by 15 in., 1 duplex compound condensing Worthington pump, size 14 and 20 by 15 by 15 in., 1 duplex compound Worthington pump, size 9 and 14 by 10¼ by 10 in. (auxiliary station), with necessary feed on vacuum pumps, etc., 1 Chicago Bridge & Iron Co.'s steel tower tank capacity 150,000 gal. Pumpage for year 1911, was 400,487,608 gallons.

THE COMPRESSED AIR PLANT FOR MINES

It Pays to Use High Economy and a Tight System

By Lucius I. Wightman

OF recent years a noticeable tendency in mining work is toward the adoption of air compressors of high economy, both for coal and metal mining service. At first thought it would not appear necessary for the operator of a coal mine to consider fuel economy seriously, but the facts in the majority of cases are to the contrary; and even where the cheapest grade of coal is used as fuel at the coal mine, managers are taking care to make it go as far as possible by means of high-efficiency steam-driven compressors.

Increasing use of high-duty compressors in the metal mining industry is the direct result of the exhaustion of rich ore bodies and the necessity for mining and treating low-grade ores which would have been considered not worth handling a decade ago. The prevailing low market price of metals, coupled with this steady movement toward large-volume, low-grade production, has forced mine managers to apply the best cost reducing methods to their operations. And since compressed air is the main reliance of the mine operator, he is giving closer attention to the problem of more economical air compression, to be realized only by the adoption of the most up-to-date and efficient compressor types. His problem is further complicated by the high cost of fuel prevalent in most metal mining districts. And even where electric power is available for mine service, the rates are usually so high as to demand every effort toward utilizing to the utmost each electrical horsepower delivered to the compressor shaft.

Features of the Straight Line Compressor

THIS type of compressor, because of its simplicity, compactness, ease of transportation and installation, and "fool-proof" quality, will always find a place for development work in new properties. Some builders are manufacturing straight line compressors with high-duty features, such as compounded steam cylinders and even Corliss steam valves; and compounded air ends are so common as almost to call for no comment. But the difficulty of getting economical regulation under widely varying load, such as is characteristic of mining work, without flywheel interferes with the economical refinement of such machines. Above 75 or 80 per cent load it may realize the fuel economy to be expected from steam compounding and be economically self-regulating below this limit, it must either be regulated by hand or left to blow off excess air through the safety valve, so that the double-tandem-compound compressor, whether either Meyer or Corliss steam valves, is but little more efficient on partial loads than a simple steam machine.

Duplex Compressors for Mines

DUPLEX compressors are rapidly dominating this field of mining service. The best modern duplex double-compound compressor maintains practically a uniform fuel or power economy over a wide load range, and will, because of its quartered cranks, run down to a low speed with only the slightest departure from the best efficiency. Where a maximum compressd air capacity must be instantly and automatically available, with an average daily load factor of around 50 per cent and probably less, the duplex compressor offers an excellent solution of economical operation.

A notable comparison of the economy of the duplex compressor with the straight line was recently reported from a Pennsylvania anthracite mine, where coal at $0.40 per ton was burned under the mine boilers. A large double-cross-compound Corliss steam compressor replaced 2 Meyer valve tandem-compound straight lines of equivalent combined capacity. The first few months of operation showed savings in fuel, water and labor realized by the new machine indicating a yearly saving of a little less than $9500, with the Corliss compressor running noncondensing. A condenser has since been installed, so that still greater savings have been realized, leading to a duplication of the equipment.

In the case just cited, comparison is between a splendid compound Corliss steam 2-stage air unit, and 2 simple-Meyer-steam, 2-stage-air straight line compressors, but another example—outside the mining field, but still typical of what might be realized in mining work—will furnish further evidence.

One of the contractors on the Catskill Aqueduct construction, New York, operated 2 different types of compressor plants on 2 sections of his work. One consisted of 4 double-tandem-compound Corliss-steam air compressors. The other comprised 2 double-cross-compound Corliss-steam air compressors, each with a capacity almost identical with that of each straight line unit in the other plant. Both plants were operated under identical steam and air pressures and vacuum, and under almost identical load conditions.

At the end of 16 months, the contractor needed more air; and to determine whether to buy straight line or duplex units for his addition, he went back over the fuel costs of his 2 plants for the previous 16 months. He found that his fuel cost for the double-tandem-compound compressor plant had been $58,000 or $5.92 per cu. ft. of free air for 16 months. While the coal cost at the double-cross-compound compressor plant had been $15,000 or $2.90 per cu. ft. of free air for 16 months. The figures showed that, had he been using the duplex compounds throughout, he would have saved $29,596 in cost of coal alone during the 16-month period. And the added saving in labor, oil, supplies and depreciation would probably have brought the total up to $40,000, or a rate of $30,000 saved a year. The contractor's order for added equipment was for duplex compressors.

The same ratio of saving could be realized in mining service, whether in coal mining where fuel is cheap, or in metal mining where coal is dear.

Power Driven Compressors

WHILE the foregoing has referred only to steam-driven compressor units, modern mining practice is tending toward a standardization on the duplex power driven type also, for mining service, for much the same reasons that have given the steam-driven duplex the preference. The power-driven mine compressor is almost invariably electric driven. The straight line type cannot be direct-connected; the duplex, on the contrary, offers ideal conditions for direct shaft driven and the writer believes that it is only a question of time when this type, in comparatively large capacities, will predominate on purely economical grounds, as it minimizes losses between motor and compressor cylinders.

With large-capacity, constant-speed, power-driven units, the only efficient means of regulation is in render-

ing ineffective, in delivery of air, part of the piston displacement. To do this on a compound straight line causes unbalanced conditions prejudicial to good service and wearing power. But the duplex permits this to be done without any sacrifice of the pressure equilibrium of the machine, and regulation under a variable load factor is smooth and easy on the unit.

Air Transmission System

NOW, having taken due care to produce compressed air at lowest cost, shall the seeking after economy in the mine air plant end here? With the drills, hoists, pumps and other air operated devices of the mine, this paper has not to do. But the delivery of compressed air from compressor to machine very properly is a function of the compressed air plant. Needless to expatiate upon the folly of making air cheap, and then sacrificing the gain through a leaky, inefficient, insufficient distribution system.

First, the receivers—they are the flywheels of the air power system, the buffers interposed between the sudden, irregular drafts of the air machines and the steady pull of the compressor. Let the receiver capacity be ample, here, if anywhere, extravagance is a virtue. Let the receivers be in the cool out-of-doors, rather than in the hot engine room. And remember that receiver drain cocks were provided to be used.

If continued trouble be experienced from freezing up at the exhaust of the air machines, put in an aftercooler to dry the air. For the water vapor which has been freezing at the machines will then be condensed, precipitated, and can be removed from the air before it enters the pipe lines. More than this, an aftercooler will send only cool air into the pipe lines, so that expansive and contractive movements due to carrying hot air and later cooling will not give rise to a leaky distribution system. And air dried in an aftercooler will prevent accumulation of water in the air lines, with "water hammer" and loss of transmission economy.

For the pipe lines, figure the diameter by the most generous formula for capacity and pressure—and then use pipe a size or 2 larger than is indicated. And remember that the maximum capacity must be provided for, whatever the average load factor that may be anticipated. For it is at moments of maximum demand that the air lines will be put to the severest test; and what shall it profit a mine manager if he gain the highest economy at his compressor and then lose most or all of his saving by insufficient air pressure at his drills? Pressure is the vital thing in a rock drill or stoper; and while "air cannot be lost" in a tight pipe line because loss of pressure means increase of volume, it is the pounds-per-square-inch on the drill piston which drives the drill hole in the least time, which means the least labor charge.

So let the pipe lines be designed to deliver both volumes and pressure—volume determining the number of machines that can be used, pressure determining the amount of work each machine will do. Abhor the short-turn elbow; cultivate the wide-bend habit. Air in motion finds as much difficulty in turning a right-angled corner as a running man or mule. Let the pipes and fittings underground be protected so far as possible from acid, water, derailed cars, and falls of rock. Let drain cocks be placed, and used, in the low places. Keep a good big air pipe always right up to the drill manifold; let the air hose be the last and smallest element in your distribution system.

And keep all joints tight. Test the pipe system at night, or on a Sunday, when all the machines are known to be stopped, by running the compressor until normal pressure shows on the receiver gage. Then see how many turns of the compressor are needed to maintain that pressure. This will show the "leakage load" and represent the waste of power going on every minute that pressure is on the system. One manager, who was cursing the voracious air consumption of his drills, was induced to make this test, and found that he had to run his machine steadily at 25 per cent normal speed, to keep up pressure on an absolutely unloaded pipe system. He decided it was cheaper to stop the leaks in his pipe lines than to install more compressor capacity and more drills. There are doubtless many others waiting to make this same discovery.

A GHOST IN THE ENGINE ROOM

By Charles G. Fenwick

BOOM-m-m-m-m. I jumped out of my chair like a shot. That dull booming sound was like nothing I had ever heard before. It was only my third night in the new plant, but I had been there long enough to know that none of the machinery ought to make a noise like that.

I must hunt trouble, so I walked around and had a look at everything. The generator was humming peacefully, the engine throbbing smoothly, and everything seemed to be quiet and contented. So I wandered back to my seat.

Boom-m-r-r-r-m! Again that uncanny soft booming sound. It seemed to me that the sound came from somewhere over the generator. But that did not seem possible, as the engine room was tightly ceiled with matched wainscoting above which was nothing but the space taken up by the rafters that supported the roof.

I went down into the basement, more for something to do than anything else, took a look at the condenser and pumps, then I went outside and looked all around the building. The yard was well lighted with a couple of arcs, but I could see nothing to cause the noise, although I noticed that the wind was getting up.

I went into the boiler room and spoke to the fireman about the noise, but he had not heard it.

The packing gland on one of the main stop valves over the boilers was leaking steam, so picking up a wrench I went up on top of the boiler and tightened up the gland. Just as I was starting down I noticed a small trap door in the ceiling over the boiler, and I called to the fireman to hand me a lantern, which I lighted; then by standing on the hand wheel of the stop valve I just managed to crawl up through the trap door. There was barely room for me to crawl on my hands and knees over the ceiling supports until I got over the engine room, and holding up the lantern, there was the "ghost."

It seems that frost gathered on the inside of the engine room roof during cold weather, then large sheets of this frost would fall onto the ceiling and melt, running through the ceiling boards and falling onto the generator. To prevent this somebody had placed a large sheet of galvanized iron directly over the generator. The power house was only single boarded above the ceiling, and every once in a while an extra strong gust of wind would blow through a large crack in the wall, causing the sheet of iron to give off a most uncanny booming sound.

SLIDE RULE FOR CALCULATING HELICAL SPRINGS

By Winslow H. Herschel

IN determining the dimensions of a helical spring to suit certain conditions, care must be taken that a certain maximum allowable stress in the wire is not exceeded, and that the spring is compact enough to go into the available space. The maximum stress in the wire, caused by a given load, may be determined by the formula:

$$K = \frac{2.546 \times P \times D}{d^3}$$

in which D = mean diameter of coil, in inches.
d = diameter of wire, in inches.
P = maximum load on spring, in lb.
K = maximum stress in wire, in lb. per square inch. For steel wire K may be taken between 60,000 and 40,000, the larger value being for the smaller size wire.

The outside diameter of a spring will be equal to D + d, and the length, when closely wound, will be about 1.1 × d multiplied by the number of coils. In the case of a spring acting in tension we must allow for 3 or 4 inactive coils at each end, in addition to the active coils required for the given scale, the scale of a spring being the number of pounds of load required to compress or stretch it 1 in. The number of active coils may be determined by the formula:

$$N = \frac{G \times d^4}{8 \times S \times D^3}$$

in which D and d have the same meaning as before, and

N = number of active coils.
S = scale, in lb. to deflect spring 1 in.
G = a factor depending on the temper of the steel, usually assumed to lie between 10 and 14 million.

While springs may be calculated by the use of tables or by means of an ordinary slide rule, I have found these methods too laborious, and have been lead, for my own use, to devise a specially graduated slide rule.

One form of such a rule is shown in Fig 1. There are 2 fixed scales, No. 1 and 6, and 4 movable scales, 2 on each of the 2 slides. The meanings of the letters P, K, S and N are the same as already explained, but there will be noticed on the slides the symbols d_1 and D_1 as well as d_2 and D_2, the former pair being used in finding the stress in wire, and the latter in finding the number of coils when the scale is assumed, or conversely, in finding S when N is assumed.

Any part of scale No. 6 may be used for P or N, or any part of scales No. 4 and 5 for d_1 and D_2, one arrow serving for d_1 and D_2. Scales No. 2 and 3 are divided into 2 parts, the longer right hand end being for d_2 and the shorter left hand end for D_1. On D_1 there is one arrow, while on d_2 there are 3 marked respectively 10, 12 and 14, referring to the factor, the torsional modulus of elasticity, previously stated to lie between 10 and 14 million. Scale No. 1 is likewise divided into 2 unequal parts, that on the right being for K, and that on the left for S. Scales No. 3 and 5 are graduated decimally, while vulgar fractions are given on scales No. 2 and 4.

In order to find the value of K, we may proceed as follows;

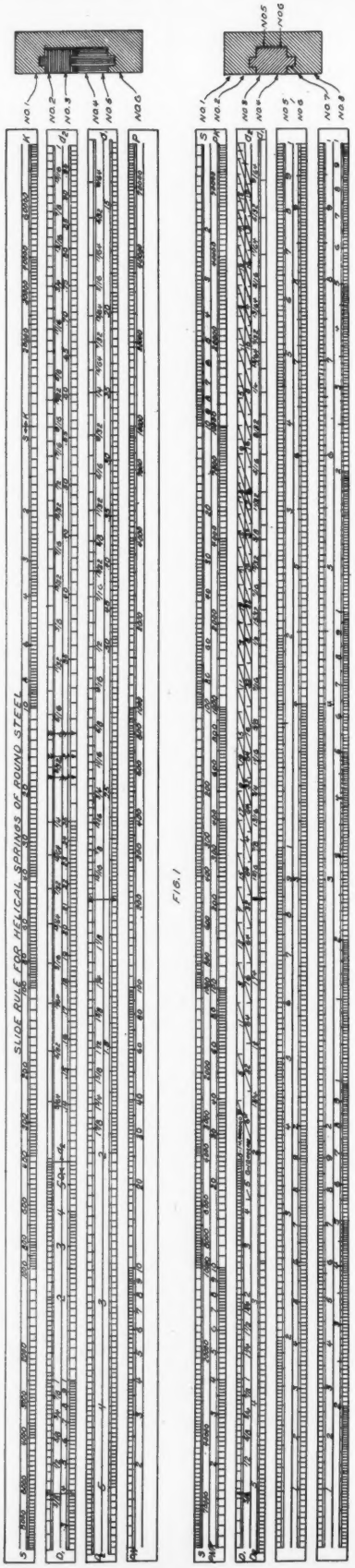


FIG. 1. SLIDE RULE WITH 2 SLIDES FOR FIGURING SPRINGS FIG. 2. SLIDE RULE FOR GENERAL USE AND SPRING CALCULATIONS

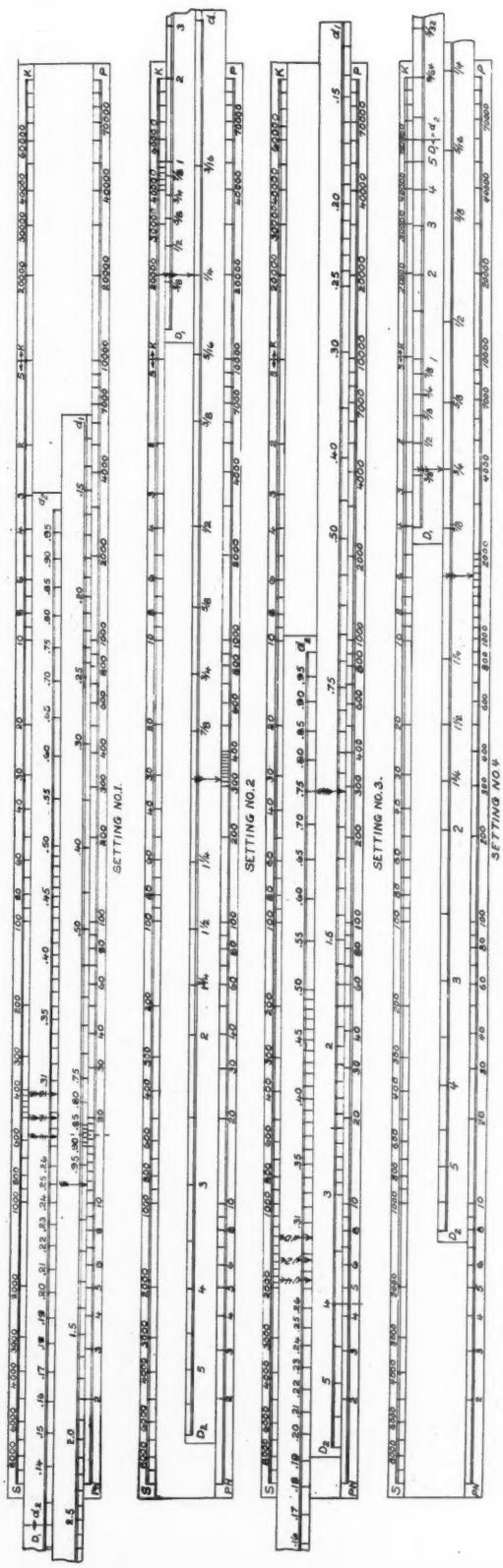


FIG. 3. RULE SETTINGS FOR SPECIAL PROBLEMS

1. Place the arrow on scale No. 5 opposite load on scale P.

2. Place the arrow on scale D_1 opposite diameter of wire on scale d_1.

3. The stress in wire, K, will then be opposite the mean diameter of coil on scale D_1.

If the value of K comes too high, d must be increased or D decreased. Ordinarily K must be kept as high as permissible, in order that the spring may be compact.

When values of d and D have been found which give a reasonable value of K, we may proceed to find the number of coils as follows:

1. Place an arrow on scale d_2 opposite the scale of spring on scale S.

2. Place the arrow on scale D_2 opposite the diameter of wire on scale d_2.

3. The number of coils, N, will then be opposite the mean diameter of coil on scale D_2.

The value of N will, of course, depend upon which of the 3 arrows on scale d_2 is used; that is, upon whether we assume the value of G to be 10, 12, or 14 million. If N is found to be too high, which is the more usual difficulty, the number of coils may often be reduced, without increasing the value of K, by increasing both d and D, in which case K should be recalculated for the new values of d and D.

In finding either K or N, it was necessary to make 2 movements of the slides. To compare this with the number of movements necessary with an ordinary slide rule, we will assume that we have recorded the values of G/8 and that we are using the lower scales of the rule. Then in order to find K we must make 3 movements of the slide and 2 of the runner, and in order to find N we must make 4 movements of the slide and 3 of the runner.

The case described is the most favorable possible for the ordinary rule, no allowance being made for moving the runner for convenience, when not absolutely necessary, nor for the possibility of having to bring the runner to 1 on the slide, in order to shift the slide to the other side of the runner as is often necessary. For example, suppose $d = \frac{1}{4}$, $D = \frac{7}{8}$, $S = 417$, and we wish to find the number of coils if $G/8 = 1{,}250{,}000$. It will be found that 6 movements of the slides are necessary, together with 5, or more conveniently 7 movements of the runner. And in the end, when the so-called answer is found, there remains the problem of finding the position of the decimal point, which in many cases takes longer than the movements of the rule. With the specially graduated rule, on the other hand, the decimal point is given in the answer as read from the rule.

Figure 3 shows, somewhat simplified, the same rule as in Fig. 1, the first setting being for the data given above. The required number of coils, read on scale N at the dotted line, is seen to be 17½.

The next problem is to determine the stress in wire if this same spring supports a load of 315 lb. As shown in setting No. 2, the stress, K, is equal to 45,000 lb. per sq. inch if $P = 315$.

Similarly, settings Nos. 3 and 4 show the method of determining N and K for a spring where $d = \frac{3}{4}$, $D = 4$. Assuming that $G = 14$ million, we find in setting No. 3 that if $S = 1854$, the number of coils, N, must be 4.2. In setting No. 4, if $P = 1657$, K is found to be 40,000.

In Fig. 2 is shown a rule which requires a runner, and which combines with a spring slide rule, one which may be used for general purposes like the Mannheim rule. P, N and K are here all read on scale No. 2,

while S is found on the reciprocal scale No. 1. The decimal divisions of d and D are omitted so that d_1, D_1, d_2 and D_2 may be brought upon one slide, D_1 being at the left and d_2 at the right of scale No. 3, and D_2 at the left and d_1 at the right of scale No. 4. Scales D_1 and d_2 have separate arrows, but one arrow serves for both scales D_2 and d_1. On scale d_2, instead of the separate arrows, as shown in Fig. 1, for different values of G, there are 2 sets of graduations, the outer being for G = 14,000,000 and the inner for G = 10,000,000. Scales Nos. 6 and 7 are used together for general calculations, the graduations being the same as on a Mannheim rule. Scale No. 5 in combination with No. 6, gives square roots, and scale No. 8, in combination with No. 6, gives cube roots directly. The slide is inverted when using scales Nos. 5 and 6.

Directions for finding K with this rule are as follows:

1. Set runner at value of P on scale No. 2.
2. Bring arrow on scale d_1 to runner.
3. Set runner at value of d_1.
4. Bring arrow on scale D_1 to runner.
5. The value of K will then be opposite the value of D_1.

To find number of coils, N:

1. Set runner at value of S.
2. Bring arrow on scale D_2 to runner.
3. Set runner at value of D_2.
4. Bring arrow on scale d_2 to runner.
5. The value of N will then be opposite the value of d_2.

It will be seen that the different values of N, due to possible variations in G, may be noted without any additional setting of the slide, such as would be necessary in using the rule shown in Fig. 1.

FROM A COAL HEAVER SON TO HIS ENGINEER FATHER

Explaining How He Got Some Real Experience and His First Raise

DEAR FATHER:

I am pleased to acknowledge your esteemed favor of a recent date and am sorry that you and mother had any anxiety because I did not write, but the truth of the matter is that I have been so interested in my work that I was not aware of the fact that time was fleeting.

I not only read your letter once, but several times, for there was so much in it that I could not absorb it all in one application. I am beginning to get quite an insight into the power house business now, and am really getting used to the hard work. There are bunches on my hands just the same as on those of any other laborer around the plant.

At first when I saw the young fellows come out of the office, about 5 every evening, and go laughing down the street, it made me almost wish that I had taken the paper route to fame (if there is any), instead of the scoopshovel route, but some how or other, Father, the longer I stay at this work the better I like it. There is a certain amount of satisfaction in knowing that one is right down at the business end of the entire works, the starting point, as it were, and when I come to look at it from another viewpoint, the engines make the wheels go, the boilers make the engines go, the fireman makes the boilers go, the coal makes the steam, and I am wheeling in coal.

I was going to say that I "made the fireman go," but that would be a little too sweeping, although it is true in a way. The chief and the fireman passed a few remarks one day last week and things are beginning to come to a head and the fireman seems to think that I am responsible for all his troubles. Well, I am, for some of them, I'll admit, but I will not shoulder all of them.

It was last Sunday that we washed the boiler, and the chief showed up quite unexpectedly and the fun commenced.

"Fred, what are you washing those boilers out with," said the chief.

"Water," said Fred, and Father, that is the only really bright thing I ever heard him say.

"What kind of a hose have you got and what pressure do you get?"

"The same hose we use to wet down the ashes, with the pressure we get from the tank," answered Fred.

"Let's see that hose. Turn on that water, Mack," and the chief took the hose out of Fred's hand. I turned on the water, and the stream that came out of it was not strong enough hardly to get out of the nozzle. You ought to have seen the look of contempt that came over the chief's face. It was a study.

"Get up there Fred, and let's see how it works," and Fred got up on the boiler, got down on his knees beside the manhole and hollowed, "Let 'er go." I turned on the water. There wasn't very much of a demonstration, that's a fact; that is, as far as water was concerned, but the chief was mad clear through.

"Say, Fred, is that the way you wash boilers?"

"Yes, how t'ell do you suppose I'm going to do it? Use a scrub brush or a mop?"

"Get inside, get inside, where you can make a job of it."

"Say, Chief," said Fred, as he straightened up on his knees on top of the boiler, "do I look anything like a muskrat or a beaver?"

"Get down off that boiler. Mack, get me an extension and we'll start right now and run this plant as near right as possible or know the reason why." And he went in to his desk, unwrapping a large package as he went.

I have been on the job long enough by this time, I hope, to know about what is wanted; so I got one of those waterproof extensions, and as I came out into the boiler room(there was the chief getting up on top of the boiler all dressed in a close fitting boiler inspector's suit and when he got up on deck he reminded me of Admiral Schley, on the bridge of the "Brooklyn."

"Mack, go in and get that small chain in the work shop and the padlock that is on my desk, and lock up the blowoff valves and bring the key to me. Fred, you go over there and sit down on the floor, where you won't fall off;" this last in about the same tone of voice that some sea captain would use, and Fred went.

"Well, in you go, Mack," said the chief, when I stood beside him.

"Chief," said I, "I never was in a boiler in my life before, and don't have the slightest idea of how to start; but if you will show me the trick, I will try and do it, but it seems to me that that hole is pretty darned small for a fellow of my size, let alone a man like you."

The chief didn't say a word, but putting both feet in the manhole, he slipped through as if he was

greased. It was so simple that it looked easy, but when I got about half in—or out, whichever you want it—I got stuck and there I was, and could not get either way.

Of course I got excited and all worked up and the more I tried to extricate myself the worse I got. Then I caught sight of the fireman sitting on the floor trying to obey the chief's instructions, and I appealed to him, but he cussed at length and told me to go some place where it was hotter than I was under the collar.

"Say, kid," said the fireman, "when you went to school and got so all-fired smart, did the p'fessor l'arn you nothin' about how to get into a boiler or how to get out if ye got stuck?"

Well there I was with my head out at least, but there was the poor Chief inside and no way to get out. After I had worked for what I believe was at least half an hour, I felt the Chief grab me by the slack of the overalls and pull down a wrinkle and I slipped through the hole and dropped in a heap on the tubes.

The Chief took the light and a little hammer that he brought along and went over the tubes closely, examining everything thoroughly tapping those iron braces and if there was anything that escaped him, I didn't notice it.

Right in under the manhole, the scale was not very thick, say, not over 1/16 of an inch. But back at the ends, it was about half an inch and in several places the tubes were scaled over solid.

Well, the chief was pretty well riled up. He dug into the scale with his little hammer and found that it could be dug off with a little exertion. He brought along a sharp chisel bar and we tried that long enough to know that it would work.

"MacDougal, do you think that you could navigate that bar up and down the length of this boiler on every tube?"

"I can."

"All right, then lets get out." And as I was nearest the manhole, I started first. Of course it is not necessary to say that I got "stuck in the draw" again, in going out. The Chief gave me a reasonable length of time and then he pulled me back in and explained how to go at it, and once shown the trick, the rest was easy.

"Fred," said the Chief, as soon as he struck the floor, "How much of that boiler compound do you use in those boilers every day?" and I saw that this was not going to be any of these whitewashed political investigations: it was going to be the real thing. Fred shifted his weight from one leg to the other several times and then asked:

"What compound?"

"Why, that compound out in the oil house in that barrel behind the door."

"Is that boiler compound?" blandly asked Fred.

"Is it compound?" sneered the Chief. "Does it look like ear corn? What do you do with it. I see that it is disappearing fast enough. Where does it go?"

"Why, I thought it was washing powder, and I have been using it to wash my overalls with."

Fred might have known that a concern the size of the Daneburg Manufacturing Co. would not buy washing powder for the firemen to wash their clothes in, and if they did, they would hardly buy a whole barrel at a time, but somehow or other it didn't seem to "soak in."

"So you wash your clothes in it do you? Well then let's see if you are as good at getting them dirty as you are at getting them clean. You get up inside that No. 3 boiler, and be almighty swift about it too, and see if you can get a ton or 2 of that scale off the inside of it. No wonder the coal bill is running up out of all proportion to what it ought to be. How often do you clean the combustion chambers?"

"What combustion chambers?" asked Fred doggedly.

"What combustion chambers? Why you infernal imbecile, the combustion chambers in under the boilers and back of the bridgewall?"

"Wh-Wh-Wh-why, I didn't know that these old leaky kettles had any," stammered Fred, "that old boiler over at Jagerson's Box Factory didn't have any and I never saw one of the things in my life."

"Well, I'll tell you one thing, right now, that you're going to learn before you are much older. You get that wheelbarrow around here and open that door at the back end of the boiler and wheel out that accumulation of ashes and soot, and we'll see if you can get those Sunday overalls of yours dirty by real work."

"But how about the scale," wailed Fred, who saw that as there was going to be 2 dirty jobs, he would at least try to land the cleanest one, if there was any choice.

"You get the combustion chambers of those boilers that are dead, cleaned right down to the brick, and then sweep the shell of the boilers clean as a whistle,—and we'll see if you can do that and do it right. I'll 'tend to the scale proposition," and as he gave Fred a look that was about 212 deg. in the shade, he said, "Come on MacDougal, and we will scare up some more help," and we went out to the timekeeper's office, where the chief selected 2 or 3 names and sent me out to find the men.

As soon as they arrived, the chief put them to work digging scale out of the boilers that were not in service.

"But where do I come in, Chief?" said I.

"Mack, if you ever expect to be an engineer you have first got to learn to fire. There is no shortcut and you may as well begin right now, while I am here to show you how and show you right," with a scorching glance at the now industrious fireman.

Well, he let me fire, and by coaching me a little now and then, I finally got so I could put in 2 scoops without hitting the door. Meanwhile he kept his eye on the fellows inside the boiler, and frequently exchanged compliments with Fred.

Along towards evening, at his suggestion, I got the wheel barrow and weighed the scale that we pulled out of the front manholes. What we took out weighed just 1044 lb. and you could hardly see where they had worked.

Well, to make a long story short, we hitched the hose on the extra boiler-feed and with about 100 lb. pressure, we washed out all that was going to come out and got the boilers ready for service next day.

Father, you ought to see the reduction in the coal burned. It was a big surprise to us all. Even Fred was forced to admit that there was a little saving at least. The chief has ordered a "knocker," not one like the fireman, but one that you run through the tubes to knock off the scale.

The assistant quit yesterday to take charge of the plant over at The Boston Store, and the chief asked me, if I thought that I could handle the job, and I told him that I wasn't going to try, for I have not learned all there is to be learned in the boiler room yet, so he raised my pay and let me stay. Love to you all,

Your loving son,

Donald C. MacDougal.

THE RITES GOVERNOR

Sketching Its Development, the Features and Principles Covered by the Rites Patents; Effects of Spring Tension and Pivot Friction

By Sterling H. Bunnell

IN spite of the attention which has been attracted by the performance of the steam turbine in electric power service, it appears to be a fact that no great diminution in the number of reciprocating steam engines has yet taken place. High-speed engines for direct connection to electric generators are still the standard for buildings of the type usual in large and small cities Some of the large central stations have put forth great efforts to convince the public that marked economy can be effected by the purchase of central station current at special rates, even when the heating system of the building consumes enough coal to generate more than the required electric current. It is, however, a matter for grave doubt whether central stations furnishing electric current by

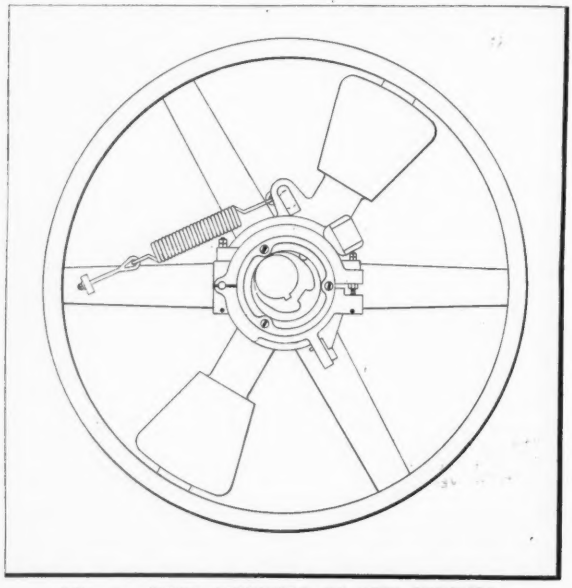


FIG. 1. RITES GOVERNOR OF THE PRESENT

burning coal under steam boilers can hope to compete in cost of current with coal burned in isolated steam plants, unless the central station has the advantage of income from a central exhaust steam heating system reaching surrounding buildings, or unless the isolated plant is extremely small, so that attendance and upkeep form an abnormal proportion of the operating expense.

Over a large part of the United States, the amount of heat required in winter is so great that electric service for a building can be furnished from the same coal which is required to produce the heat without generating power. Light and heat are required in the same season, so that increase in lighting requirements accompanies increase in heating. Electric light and power are virtually by-products of the heating plant. In every case where the heating plant is of moderate or large size, the addition of engines and engineers increases the operating cost in so small a proportion that the cost of power produced from such a plant is below the cost of power produced from a central station under any but the most remarkably favorable circumstances of generation and distribution as well. This fact has long been recognized by the builder of high-speed steam engines for electric light and power service.

Obviously, in the small station, unnecessary refinements are to be avoided; simplicity and reliability are at a premium in the isolated plant. It is necessary to operate such plants without excessive expense for engineers, while the character of the service to be maintained imposes severe conditions upon the engines as to regulation of speed and power. The gradual improvement of the high-speed engine into its present form has been a matter of 20 years or more. The engines of today resemble those of 15 years ago, in general. The principal differences are in the increased weight of the working parts, and in the almost universal use at present of the Rites governor.

Designs of the various makers have approached so close to a standard that it is hard to tell the engines apart, except for one familiar with minor details of the several makes. The Rites governor, in particular, forms a point of almost absolute similarity between the various engines.

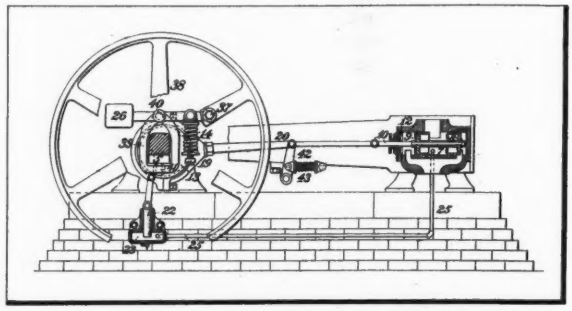


FIG. 2. RITES PATENT OF 1886

It must not be supposed, however that this governor reached its present state of perfection at a single creative stroke of invention. A study of the various patents granted to Francis M. Rites for steam engine governors and parts accessory thereto, covering a period from 1886 to a recent date, is of great interest to one familiar with the principles and details of this governor as now designed for practical use.

Principles of Action

THE Rites governor, shown by Fig. 1, consists essentially of a single cast-iron weight of elongated form, carried by a single heavy pin located near the axis of the flywheel, and restrained against the action of various forces by a single spring. Nothing simpler can well be imagined. The earlier high-speed engines embodied centrifugal shaft governors consisting of 2 weights of equal size, connected by a link rod giving them equal motions to and from the rim of the governor case or wheel which carried them, 2 springs, one for each weight, an eccentric and strap, and the necessary links between the eccentric, and one or both of the weights. These governors thus contained from 12 to 20 parts. Any failure to make the various parts exactly alike in weight and strength threw the construction out of balance and imposed undesirable strains on the various bearings.

The accompanying diagram of the Rites governor, moreover, shows the essential points which affect its practical operation. It will be seen that the weight is unbalanced as to gravity, and will tend to fall forward

during half the revolution of the wheel and fall backward during the other half. There are other disturbing forces in connection with the governor. The valve stem, having a steam pressure tending to force it outward, reacts on the governor arm to push it one way during half the revolution and the other way during the other half. The inertia of the valve and valve rod, rocker arm and eccentric rod, acts as a drag to resist the movement of the eccentric pin in the governor arm, and tends to pull the arm from its position, but this force, unlike the last, operates always in the same direction with respect to the rotation.

Upon study, inertia of the valve gear will be seen to operate in the same direction as the pull of the spring, so that an increase of weight of valve gear has precisely the same effect as tightening the spring of the governor; that is, it increases the speed of the engine. Stuffing-box friction of the valve stem operates in the same way as inertia of the valve gear, though not timed the same. Tightening the packing therefore tends to speed up the engine.

All these points are familiar to those who have to do with adjustment of Rites governors; but they were by no means self-evident, and judging from the record of the patents, must have caused the designers a good deal of anxious thought.

First Designs

THE first patent of Mr. Rites which appears to relate to any feature of the governor as now used, is 342,307 of May, 1886. The illustration shows a horizontal engine with a single weight governor—very much of the Sweet type. Such a governor is subject to gravity and other forces which tend to disturb its position materially. The inventor has provided, to counteract these forces, a pressure piston bearing vertically upward under the eccentric strap and balancing the downward effect of gravity. Similarly, he has overcome the inertia and frictional effects of the valve gear by interposing a rocker arm and spring. These devices in some form are familiar to all designers of medium speed engines with Rites governors, though they are by no means found necessary in every case, and Rites governors have been made to operate at moderate speeds without any such external balance.

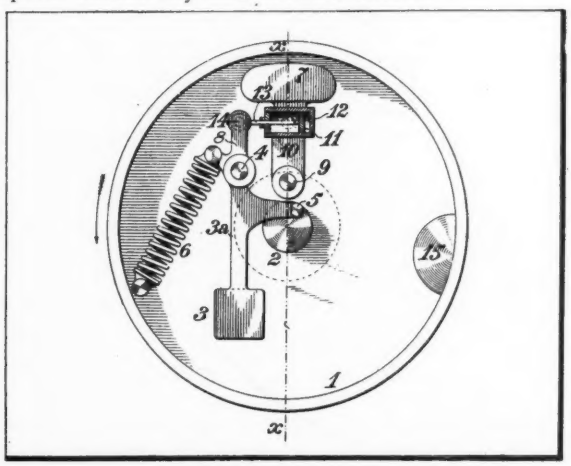


FIG. 3. TWO-WEIGHT GOVERNOR OF 1894

Patent 355,717 of January, 1887, shows the familiar Westinghouse vertical engine with its inclined piston valve. Here the balance has been effected by placing an eccentric arm opposite the governor weight arm, the 2 having equal moments, so that the governor is balanced in every position. This governor, however, is far from the Rites governor as it is now known.

Patent 384,485 of June, 1888, is jointly in the names of H. H. Westinghouse and Francis M. Rites, and shows a governor of the familiar 2-weight type, having 2 springs and all parts balanced against each other, but enclosed in an oil casing which is the feature of the patent. These inventions are obviously of slight relation to the standard Rites governor.

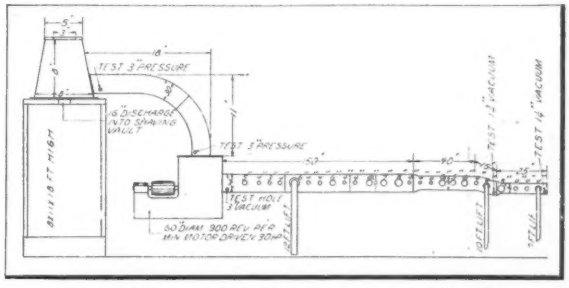
(To be continued.)

TROUBLE WITH CYCLONE

I HAVE had some changes to make in part of the factory and have wanted a test made of our cyclone to see if any changes were necessary in the blower system. We have had some trouble with burning out coils of the motor and throwing the belt off when all the pipes are opened. The accompanying sketch shows the arrangement and the results of the vacuum test made. Please advise if anything can be done to better operating conditions. W. G. Brush.

We do not wonder that this party has had motor troubles. As near as our engineer can figure from the information at hand, this fan takes approximately 32 hp. delivered to the fan pulley when all the pipes are open. This, allowing for the inefficiency of the motor, would show this 30 hp. motor taking somewhere about 38 hp.

Although the engineering of this job is much better



CYCLONE SYSTEM WHICH GIVES TROUBLE

than the average, it seems that the system has become very much over-loaded.

To get the best engineering results out of a No. 60 fan, it should not exhaust from over 224 sq. in. of pipe openings. This system is exhausting over 515 sq. in. We do not wonder at the 3 in. back pressure near the cyclone on account of its extreme over-load. It would seem to us that the better remedy for this would be to add a new system in connection with the present one, leaving 224 sq. in. area and putting in a new system of a capacity to handle the 291 sq. in. remaining. This would cut off the back pressure almost entirely and would reduce the horsepower for both systems to 22.

BIRMINGHAM (ALA.) HYGIENIC ICE COMPANY'S new plant is nearing completion near the Atlanta, Birmingham and Atlantic railroad yards, on the South Ensley car line. The plant is said to be the largest ice factory in the south.

The new plant will manufacture a superior quality of ice, along the most sanitary lines. Experts in the ice-making business, attracted by the modern machinery being installed, have been to see the plant, all of whom pronounce the new structure as second to none in the country.

PROTECTION OF REFRIGERATING APPARATUS*

Precautions to Guard Against Corrosion

By Morgan B. Smith

AVOIDING corrosion in refrigerating apparatus involves 3 main considerations, namely: The metallic apparatus, the brine solution and the relation of the apparatus proper to other apparatus in the vicinity, with regard to avoiding the generation of electric current.

If we place 2 electrically dissimilar metals, such as brass and iron, in a brine solution, an electric current is at once set up. This will pass from the iron to the brass through the solution, thus carrying the iron into solution, and forming the familiar oxide called rust. The amount of the corrosion thus caused depends on the size of current set up.

One metal should, therefore, be used as far as possible, and it should be of the greatest possible purity, for impurities in the metal itself act in much the same manner as 2 different metals. This is especially true of cast iron, which is frequently destroyed by local current between the iron and impurities contained.

Galvanized Iron

ZINC resists corrosion in a brine solution if no electrically dissimilar metal be present. If, however, iron is present the zinc will go into solution, thereby protecting the iron as long as zinc is present in sufficient amount. Therefore it is plain that galvanized iron should never be used except that of the very best quality, in which no iron whatever is exposed. When galvanized iron does show iron exposed at pin holes, or along seams where bending has cracked the zinc film, it is next to worthless in brine solutions, for sooner or later all the zinc will be stripped off, leaving the iron bare.

It is doubtful, therefore, if galvanized iron should ever be used, since it seems almost impossible to construct apparatus of this material so that only zinc will be exposed to the brine solution. Many alloys resist corrosion to a marked degree, especially the bronzes. Alloyed copper in iron tends to retard corrosion, whereas unalloyed copper in iron greatly hastens corrosion. From the foregoing facts it is very evident that but one homogeneous metal should be used as far as is practical in the construction of apparatus.

Design of Apparatus

DESIGN of apparatus, especially of fittings and piping, is very important and is generally wholly neglected. When a piece of metal is strained, an electrical difference of potential is at once set up between the strained and the unstrained portions, and it is the strained portion which is attacked and eventually destroyed.

This state of affairs is exemplified in the case of threaded pipe ends engaging fittings, the pipe ends being strained while the remainder of the pipe is unstrained. There can be no doubt whatever that this state of strain in pipe ends is largely responsible for the failure of piping at the threaded portions.

This is almost equally true of fittings, which, however, generally have so much more metal remaining after the threads are cut that the strain caused in them when making up joints cannot be as great as it is in piping where comparatively little metal is left after threading. There are a number of instances where pipe trouble has been eliminated by the use of piping and fittings of extra weight, so that, after the threads are cut, there is left an abundance of metal sufficient to withstand the making up of joints without undue strain.

Experiments have proved that torsional strain is far worse than tensile strain, although in brine lines it is often evident that both types of strain are inflicted at the time of erection.

A heavy brine at high pressure exerts a severe cutting effect at turns under the impulse of the brine pump. It is well, therefore, to use bends of as great radii as possible, wherever practical, as the average life of long-turn bends far exceeds that of short-turn bends under the same conditions. Air is one of the great accelerators of corrosion, and it is essential to see that no air pockets can form in the apparatus, especially in the piping. All high points in the piping and each piece of apparatus, as far as practicable, should be provided with suitable vents, so that any trapped air can be withdrawn from time to time. If an air pocket does exist at a point for some time, corrosion soon makes itself manifest, and if allowed to go on will eventually cause failure at that point.

Brine Solutions

SINCE the brine is made up by dissolving certain chlorides in water, it is evident that the nature of that water is sure to affect the resulting brine solution. Water containing acid of any description should never be used, since the resulting brine will also be acid. An acid brine is far more corrosive than a neutral or an alkaline brine.

As a matter of fact, all brine solutions should be tested from time to time for acidity, and, if found to be acid, they should at once be neutralized with some alkali, such as lime or caustic soda. Sufficient alkali should be added to make the brine distinctly alkaline towards a suitable indicator.

The best indicator for this purpose is phenol-phthalein. This is made up by dissolving phenol-phthalein in alcohol, about ½ ounce in 2 quarts, and adding to this solution 2 quarts of distilled water.

Another good indicator which may be used in conjunction with phenol-phthalein is methyl-orange, which is made up about 1/10 ounce per gallon.

If the brine is alkaline, as it should be, a pink color results when a few drops of phenol-phthalein are added to a small sample of the brine. If the brine is acid or neutral, no pink color results.

If the brine is alkaline, as it should be, a yellow color results when methyl-orange is added to a small sample of the brine. If the brine is acid a red color results. It is well to use both indicators, as one checks the other.

When making up brine it is well to avoid saturating the brine with air, for brine saturated with air is far more corrosive than brine carrying only a minimum amount of air in solution. Brine should never be agitated with an air-blast, nor should it be allowed to fall through the air into tanks, as is often the case with return-brine. Return-brine is often very nearly saturated with air in just this manner.

As for the strength of the brine and the temperature, it is certain that the greater the concentration

*From a paper before the American Society of Refrigerating Engineers, read at St. Louis.

and the lower the temperature the less likely is the brine to assist corrosion.

Selection of the chloride to use in making up the brine solution is no longer a serious problem, since practice and laboratory experimentation have proven the truth of the assertion that the most economical and the least corrosive chloride is that calcium chloride which contains as small an amount of magnesium chloride and of sodium chloride as possible, and the least practical amount of water.

There is no longer any doubt that magnesium chloride and sodium chloride in calcium chloride brine materially increase the corrosiveness of the resulting brine, compared with a brine containing practically no chloride other than calcium chloride. This is especially true if the brine containing magnesium chloride becomes acid through the unstable nature of magnesium chloride.

I have been asked whether ammonia present in brine would increase the corrosiveness of the brine. Experiments of long duration, in which the ammonia content of the calcium chloride brine in question was maintained at a constant value, show that ammonia tends to retard corrosion, rather than hasten it, when present in sufficient amount.

Generation of Electric Current

CORROSION which we have considered so far has to do with the inherent relation between unlike metals and an electrolyte, which in this case is the brine solution. Such corrosion may be greatly hastened by the action of stray electric current, which finds a way into the refrigerating apparatus, from which it passes to some neighboring metallic circuit, or directly to ground.

If the refrigerating apparatus, in whole or in part, is positive in electrical potential towards ground, we may be sure that some stray electric current is finding its way into the apparatus, and that corrosion, local or general, is being hastened along in proportion to the magnitude of that stray current.

Not many engineers realize the truth of this assertion, namely, that it is the small currents which cause the most trouble, since they are not looked for in testing, and so are able to go on and on in their destructive action. Wood says, in his book on "Rustless Coatings," that "a difference of potential of 1/1000 of a volt is all that is required to start ferric corrosion 2 miles from the dynamo.

Therefore, in testing out refrigerating plants, it is essential to make the tests sufficiently delicate to detect currents of as low a potential as 0.5 millivolt or lower. Tests made of many plants show that potentials as low as 0.4 millivolt have set up severe local action, which finally resulted in the failure of apparatus at that point. Some of this trouble comes from faulty conduits, which are neither properly insulated from their supports, nor properly grounded; some from poor wiring, since very often wiring is found in actual contact with the brine lines.

Any or all of the above conditions cannot do otherwise than assist corrosion. If current finds its way into an improperly installed conduit, that current is bound to find a path to ground. This path is very certain to be a metallic pipe, and is very likely to be the brine line of the refrigerating apparatus. It is a wise precaution, therefore, to see that current apparatus of all sorts is properly installed, so that it will not be a continual menace to the refrigerating plant.

STEEL VS. WROUGHT IRON IN REFRIGERATING WORK*

By P. DeC. Ball

IN treating iron ore, it is first put into the blast furnace, mixed with coke and limestone in the proper proportions, and the coke is burned at high temperature by hot air blast. Limestone combines with the foreign matter in the ore, forming a fluid which when cold turns into clinker and cinder.

As the iron is the heavier it settles to the bottom of the furnace and is drawn off into moulds, making pig iron which runs from 94 to 95 per cent pure metal, the balance being carbon, silicon, manganese, phosphorous and sulphur, of which less than 4 per cent is carbon, about 1 per cent manganese, less than 1 per cent silicon, one-tenth of 1 per cent phosphorous, and the balance sulphur.

Manufacture of Wrought Iron

TO make wrought iron in a puddling furnace, the pig is melted or boiled with an oxidizing cinder, the puddler, or man operating the furnace with his helper, gathering the molten particles of refined iron together in the form of a ball. The temperature in the furnace is not hot enough to melt the refined iron, which soon becomes like putty and is withdrawn from the furnace in balls of 400 to 500 lb., mixed with considerable cinder, taken to the hammers and eventually hammered and rolled into bars about 1 in. thick and of the desired width.

These bars cut and piled 4 or 5 high are reheated to welding temperature and rerolled into a plate of the desired thickness and width. The process reduces the oxide and slag to about 2 per cent, silicon one-tenth of 1 per cent, phosphorous two-tenths of 1 per cent, and the sulphide between 1/100 and 2/100 of 1 per cent with trace of manganese and carbon.

Manufacture of Soft Steel

TO make what is known as soft steel, the pig iron is taken to the mixer in much larger quantities than to the puddling furnace and is melted and mixed by agitation. Then it goes to the converter where air is forced through the melted mass, causing oxidation, the silicon and manganese being first attacked. As the temperature increases, the carbon begins to oxidize rapidly, and the color of flame tells when the carbon has been sufficiently burned out. Slag and cinder rise to the top and the steel is drawn off into moulds, making ingots from 8 to 20 times as large as the balls of puddled iron.

The characteristic differences are about as follows: In wrought iron there is a trace of carbon, while soft pipe steel has approximately 0.07 of 1 per cent; wrought iron has 0.15 of 1 per cent manganese, while steel has 0.03 of 1 per cent; wrought iron has 2 per cent of oxides and slag while steel has less than 0.15 of 1 per cent. As a matter of fact what is now designated as steel pipe is in fact a purer iron as is shown by heating a piece of steel pipe to a high temperature, chilling it suddenly in water, and then crushing it, when it shows much the same characteristic as wrought iron.

Properties of the Materials

WROUGHT iron skelp and pipe steel skelp, have the following physical properties as an average:

Wrought iron will vary from 4 to 16 per cent in elongation, whereas steel may be expected to range between 19 and 25 per cent.

*From a paper read before the American Society of Refrigerating Engineers at St. Louis.

Puddled iron pulled transversely seldom gives 35,000 pounds per square inch tensile strength, and the elongation and reduction in area are proportionately low and variable.

Pipe Welding

THE majority of pipe that refrigerating engineers have to deal with is from 2 in. in diameter down, and is made by the butt-weld and lap-weld process; 1¼-in. pipe and under is butt-weld unless redrawn.

In butt-welding small pipe the skelp or plate is heated to a welding temperature throughout and drawn through a bell-shaped ring; the edges of the plate are forced together and welded, passed through rolls to give the correct outside diameter, and then through the cross rolls to straighten and finish. After cooling the ends are cut off, threaded and tested. As the hydrostatic test is made by blanking each end of the pipe with two tight heads, laminations in wrought iron pipe are seldom detected.

Lap-welding consists of 2 operations. The skelp or plate is heated, passed through rolls and the edges chamfered or beveled, bent longitudinally so that the 2 beveled edges overlap, forming the pipe roughly. It is then heated again to a welding head, and goes through the welding rolls. A mandrel, or oblong piece of cast iron, is held in position between the rolls, so that the welding takes place on the mandrel and between the rolls; the skelp at a welding temperature passing over the mandrel, between it and the rolls.

This reduces the lap where the original plate was beveled to the same thickness as the rest of the plate, and welds it thoroughly, which in lap-weld pipe is approximately as strong as any other portion of the wall. While still hot it goes to the sizing rolls, straightening rolls, etc., through the same process as butt-weld pipe.

Steel pipe, owing to its being made from more regular material, has great ductility, and comes out a smooth finished product. We present the table showing the average of bursting tests on steel and wrought iron pipe 1¼ and 2 in. diameter, furnished by F. N. Speller, member of the Engineers' Society of Western Pennsylvania.

We have found from personal experience that steel pipe is threaded or chased as readily and perfectly as wrought iron pipe, provided that the dies or cutters have the proper rake. Dies for threading wrought-iron pipe require much less rake, only about 12 deg., than dies to chase steel pipe, which, to get best results, should have about 18 deg. rake. It requires, however, approximately 6 per cent more power to thread steel pipe when proper dies are used, but as the torsional strength of steel pipe is much greater than wrought-iron pipe, there is much less danger of twisting steel pipe or opening the weld during the process of threading.

AVERAGE BURSTING PRESSURE OF STEEL AND WROUGHT IRON PIPE

Size, Inches.	Kind of Pipe.	Length.	Number of Samples Tested.	Average Weight per Foot.	Average Thickness.	Average Bursting Pressure	Average Maximum Stress per Sq. In. on Wall of Pipe. (Barlow Formula).
		Ft. In.		Lbs.	Inches.	Lbs. per Sq. In.	Lbs.
1¼	Standard butt weld steel	18 0	10	2.26	.139	5,808	34,600
1¼	Standard butt weld wrought iron	18 6	10	2.21	.147	4,891	29,800
1¼	Standard butt weld wrought iron	17 6	10	2.21	.136	5,283	30,900
1¼	Standard redrawn butt weld steel	15 0	14	2.21	.136	7,400	44,800
1¼	Extra strong butt weld steel	20 0	11	2.86	.181	10,640	54,000
1¼	Extra strong butt weld wrought iron	20 0	10	2.95	.188	5,895	26,700
2	Standard lap weld steel	20 0	10	3.67	.155	6,645	51,000
2	Standard lap weld wrought iron	20 0	10	3.65	.152	3,213	*25,100
2	Standard butt weld steel	19 0	11	3.53	.153	4,951	43,400
2	Standard butt weld wrought iron	17 6	10	3.70	.156	3,687	28,600
2	Tubing (4 lb.) lap weld steel	21 6	10	4.26	.178	7,361	47,800
2	Extra strong lap weld steel	18 6	10	5.01	.218	7,909	43,300
2	Extra strong lap weld wrought iron	20 0	10	4.79	.206	6,349	36,500
2	Extra strong butt weld steel	20 9	10	5.06	.220	7,661	41,700
2	Extra strong butt weld steel	20 6	10	4.91	.213	8,238	45,900

* Purchased as lap weld but looks like "butt weld."

Corrosion Resisting Qualities

WE have now to consider the resisting qualities of the material to corrotion of wrought iron pipe, with its laminations and slag, and soft steel, almost a pure iron, regular in quality and material.

In ice-making and refrigerating brine tanks, where the pipe was at all times submerged in brine, the old laminated pipe gave no trouble from pitting or corrosion, but in submerged condensers we more especially noted heavy pitting in spots. The conclusion we came to in the latter 80's was that of galvanic action—the metal positive, mill scale or slag negative. This conclusion was borne out latter by the tests of the Bureau of Steam Engineering of the Navy Department.

In our personal experience we have never known submerged pipe, iron or steel to corrode in an ice tank or brine tank to an extent to cause trouble, and we have taken out coils in these tanks after 15 years' service, both iron and steel, and used the pipe in making new coils.

This does not apply where the practice is to expose the pipe for several months in the year to the oxidizing effect of salt, air and moisture, as is done in some plants.

The surface or open air type ammonia condenser is of necessity exposed to all corrosive effects, air contaminated by all gases, sulphurous included, and water containing all minerals, heat and cold. We as yet have been unable to find wherein steel pipe is not as good as, or better than wrought-iron pipe, and believe that each particular case of corrosion is caused by local conditions, such as stray electrical currents or contaminated air or water, as stated. We have found as high as 30 per cent of genuine wrought-iron pipe defective, and never more than 7 per cent of steel pipe, the average steel pipe defective at 500 lb. air test under water being less than 2 per cent, and generally this defect resulting from the mill being too economical and cutting the pipe too near the long end.

Defective Iron Piping

IRON pipe, however, when it runs bad, runs very bad. This, we think, is caused by the large variation in quality of material, and especially as now it is the practice to use steel scrap of various composition, and the slag is not always uniformly distributed. We call to mind a case where the pipe made up into coils and

tested under water showed many leaks from end to end, sometimes in the center only.

The pipe was so bad we sent a portion of it back to the mill, and had a sample tested to see if it really was wrought iron. It was wrought iron, and the mill came back and stated they had tested the pipe to bursting, and could find no leaks in it. We again tested other pieces which leaked, and the same leaks developed.

We then had a man come from the mill to see this pipe tested. Some of it leaked so badly it blew the water out of the testing tank. We then tested the pipe as is done in the mill by blanking each end, and the pipe was absolutely tight.

Upon close investigation we found the iron laminated, the air going into the laminations in the wall of the pipe at the ends, and coming out through many holes caused by slag and other impurities in the center of the length. When this pipe was screwed up into fittings it necessarily leaked badly. When the ends were blanked off and the wall of the pipe sealed at the ends, as is done at the mill, the pipe showed tight.

You can imagine what this would do if the mill had galvanzied this pipe, the spelter soldering over defects in the center of the pipe, and therefore showing no leak under air pressure. But the ammonia, which would soon eat out the spelter, would certainly give the engineer, as well as the contractor, trouble.

Galvanizing steel pipe, owing to the uniform quality of material, absence of slag and laminations, makes it ideal for ammonia condensers, while galvanizing iron pipe for the same purpose is a trouble-maker, for the reason that the pipe is pickled or cleaned by sulphuric acid, hot, that eats off the mill scale and any slag it can find, and sometimes into the interior of the pipe, which is then galvanized. It stands the air under water test, is made up into condenser stands, erected and put into operation. The ammonia decomposes the spelter with which the pipe was galvanized, and the leaks begin.

We last year took down, moved and rebuilt an open-air ammonia condenser which had been in operation fourteen years, and which was made of steel pipe, full card weight, not galvanized. The pipe was in absolutely perfect condition, neither pitted nor corroded at all; in fact, looked as good as after the first 3 month's run.

Local Conditions Govern Corrosion

FROM 33 years of personal observation, constructing, erecting and operating ice-making and refrigerating machines, absorption and compression types, and using iron pipe for the first 14 years and iron and steel pipe for the next 19 years, we are convinced that local conditions only govern the corrosion of pipes in refrigerating and ice-making machines, and that, chemically and mechanically, mild steel pipe meets the requirements of the refrigerating engineer in all respects, and better than any other pipe, for the reason that it is superior in point of finish, strength, strength of seam and uniformity of material.

We think we are borne out in our conclusions by the fact that our understanding is that more than 90 per cent of all tubular goods are today made from mild steel, and that the specifications for "genuine wrought iron pipe," which some purchasers of refrigerating machines specify, require a careful, personal supervision of the contractor or his engineer to see that his contract is filled as specified.

COST TO MANUFACTURE ICE

I WOULD like to have a record showing the itemized cost of an ice plant. We are paying 75c a 100 lb. (always short weight) and a number have asked about the cost of plant and manufacturing.

We boast about our cheap fuel (oil) and electric power, so the cost should not be any higher to say the least, than in the middle west. P. A. W.

A. Of course, costs will vary more or less in different parts of the country according to the cost of fuel and cost of labor, but the following data will give you something on which to base your own estimates.

Gueth, in his Pocket Manual for Refrigeration Engineers, says that an absorption machine under the right conditions should produce up to 12 tons of ice per ton of coal burned. Actual results show 10 tons of ice sold per ton of coal bought.

For a 50-ton plant actual costs follow:

Coal at $2.20 per ton, 22 cents; labor, 34 cents; ammonia, 6 cents; incidentals and repairs, 24 cents; interest on investments, 25 cents; taxes and insurance, 11cents. Total cost to produce 1 ton of ice, $1.26. The factory cost, leaving out interest, taxes and insurance, is 86 cents per ton of ice, including repairs.

A compression machine with compound condensing engine and all pumps driven by the compressor engine, would require 130 hp. rating for a 50-ton ice plant, and with an evaporation of 7 lb. steam per pound of coal in the boilers this would require the burning of 4½ tons of coal a day, or 11 tons of ice per ton of coal burned. The cost of operating a 50-ton compression plant would be about as follows:

Coal at $3.20 per ton, 32c; labor, 34c; ammonia, 3c; incidentals and repairs, 18c; interest on investments, 25c; taxes and insurance, 11c, or a total of $1.23 as the cost of one ton of ice. The factory cost, leaving out interest, taxes and insurance, would be 87c a ton.

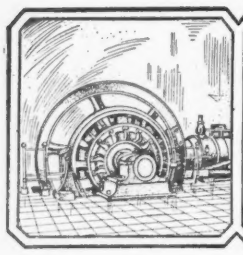
By a combination absorption and compression system, assuming a 100-ton plant, a 30-ton compression machine will drive a 70-ton absorption machine by the exhaust steam from the first machine and will turn out 14 tons of ice per ton of coal. The cost of operation per ton of ice would then be: Coal at $2.20 a ton, 16c; labor, 30c; ammonia, 5c; incidentals and repairs, 21c; interest, 25c; taxes and insurance, 11c, or total of $1.08 a ton. The factory cost would be 72c a ton.

Schmidt, in his book on Artificial Ice Making, gives the following data:

Cost of installation for the can system, $5.50 a ton; for the block system, $6.50 a ton; plate system with direct expansion plates, $8 a ton; plate system with brine plates, $10 a ton.

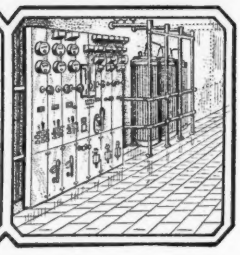
He gives as operating costs, 8¾ lb. of coal per ton of ice-making capacity per hour, and with the wages of engineers at $2.50 to $5 a day, oilers $2 a day, firemen $1.50 to $1.75, laborers $1.25 to $1.50, coal at $2 a ton, he gives as the expense for a 60-ton plant: Engineers, $9 a day; oilers $2; firemen $4.50, labor $4.50; coal $18; oil, waste and sundries $4, or a total operating expense daily of $42.00, making a cost per ton of ice of 70 cents. This does not, of course, include anything for interest, insurance or taxes, nor does it include the cost of handling the ice outside the plant and delivering to customers.

Based on these same figures he gives the cost in a 10-ton plant as $1.26 per ton; 25-ton plant as 87 cents a ton, and in a 100-ton plant as 61½ cents a ton.



Electrical Machinery

For Generating, Transmitting and Using Current



ELECTRIC MOTOR CONTROL*

Circuit Breakers, Types and Arrangement for Motor Circuits; Current Capacity of Motors, Control of Alternating Current Motors

RESPECTIVE merits of circuit breakers and fuses have been so clearly defined in the past that little discussion is necessary. Some of the more important characteristics are:

Greater continuity of service, lower cost of maintenance and positive operation between wide limits of calibration. Where a time element is desired, it can be secured through the agency of proper attachments, and positive operation is assured within wide ranges of adjustment.

Circuit breakers without time delay attachments have an inverse time element but for all practical purposes may be considered instantaneous in their operation on overload.

In the design of circuit breakers 2 general principles are commonly used to effect the rupturing of the

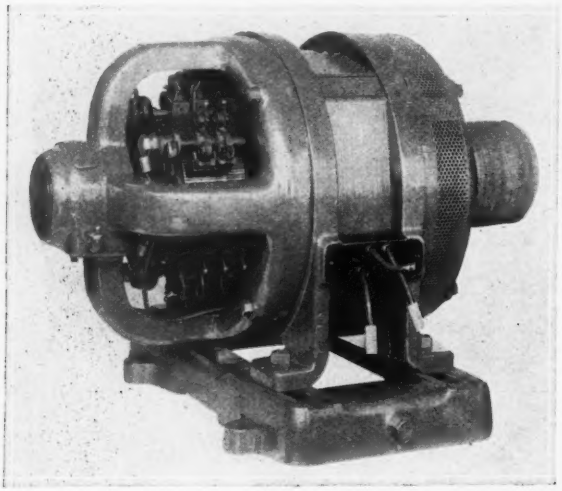


FIG. 33A. GENERAL ELECTRIC REPULSION INDUCTION MOTOR

arc between contacts when opened on heavy overload.

In the magnetic blowout type the arc is extinguished between auxiliary contacts confined by a chute in which the arc is rapidly blown out due to a powerful magnetic field from one or more electro-magnets. This type may be used in air or water-tight boxes and is peculiarly adapted for service where the arc must be confined.

In the carbon break type the arc is finally ruptured between carbon secondary contacts. In this type the slight tendency of the arc to rise due to its heat is greatly augmented by the electro-magnetic field due to the current in the arc and the arrangment of the secondary contacts. On very severe overloads the conducting arc gases may rise to a considerable height, and on this account circuit breakers should be mounted

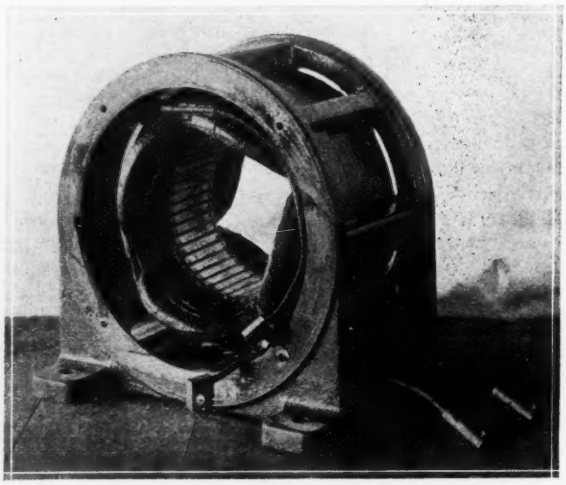


FIG. 33B. FIELD OF GENERAL ELECTRIC REPULSION INDUCTION MOTOR

at the top of the switchboard panels unless the kilowatt capacity of the plant is small. Carbon break circuit breakers should not be enclosed in air or water-tight boxes. If installed in cabinets, ample air space and vents must be provided.

FIG. 33C. ARMATURE OF GENERAL ELECTRIC REPULSION INDUCTION MOTOR

Circuit breakers for alternating current are similar in appearance to corresponding direct-current breakers. Similar coils are used but the iron circuit of the electro-magnet is made of thin laminations of soft iron and the circuit breaker frames are designed to prevent heating due to eddy currents and hysteresis and to reduce the impedance of the coil.

*Continued from page 241 of the March 1 issue.

The automatic operation of a circuit breaker is usually accomplished through the medium of an electro-magnet energized by current flowing through a coil of wire, or its equivalent, surrounding at least one pole of the magnetic circuit.

This coil may be wound for either current or potential, depending upon its method of connection

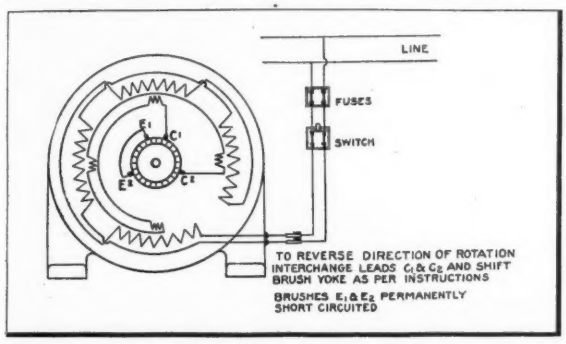

LINE
FUSES
SWITCH
TO REVERSE DIRECTION OF ROTATION INTERCHANGE LEADS C1 & C2 AND SHIFT BRUSH YOKE AS PER INSTRUCTIONS
BRUSHES E1 & E2 PERMANENTLY SHORT CIRCUITED

FIG. 34. DIAGRAM OF CONNECTIONS FOR STANDARD GENERAL ELECTRIC CONSTANT SPEED TYPE R I MOTORS

in the circuit. The current coil is connected in series with the circuit and designed to carry all the current flowing in that circuit.

Power of the electro-magnet depends on the amount of current flowing and not on the voltage of the circuit.

There are quite a number of special attachments for circuit breakers that are designed for unusual conditions, but they do not change the general principle of operation.

Selection of Circuit Breakers

ELECTRICAL circuits are generally subject to overloads of greater or less duration, and due consideration should be given to this fact in determining

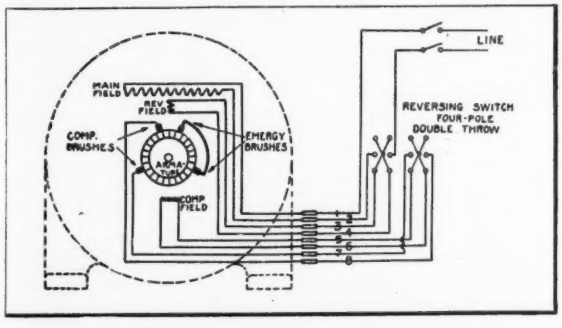


FIG. 35. DIAGRAM OF CONNECTIONS FOR REVERSING GENERAL ELECTRIC CONSTANT SPEED TYPE R I MOTORS

the current capacity of the breaker to be used. The construction of circuit breakers is such that the maximum temperature is reached in about 2 hours and they should therefore have a continuous capacity equal to, or greater than the one or 2 hour overload current of the circuit.

The selection of circuit breakers by this method allows an ample factor of safety in the matter of heating and gives a good range of calibration. Nearly all makes of standard circuit breakers are calibrated from approximately 50 to 150 per cent of the rated capacity in the smaller sizes, and have a much greater range in the larger sizes.

Ampere Capacity of Motors

EFFICIENCIES of both alternating and direct-current motors are liable to vary 10 or 15 per cent, and the power factors of alternating-current motors vary over an even wider range. It will be seen therefore, that the common practice of allowing a kilowatt input per horsepower output frequently gives incorrect results. The following formulas are given to assist in determining the capacity of the circuit breaker required; the breaker should have an ampere capacity not less than the one or 2-hour input of the motor.

$$\text{Two-hour overload current} = \frac{\text{Horse-power output} \times 746 \times 1.25}{\text{Volts} \times \text{Efficiency} \times \text{Power Factor} \times \text{Constant}}$$

If motors are rated in kilowatt output, use the following formula:

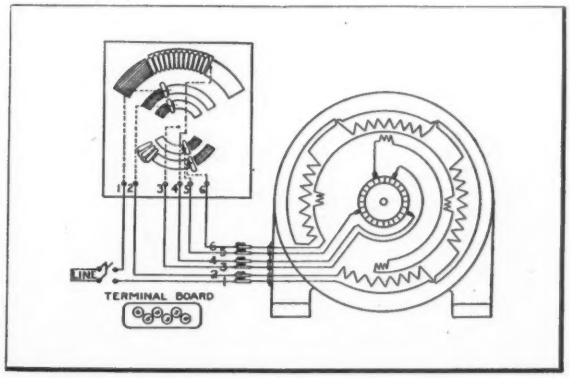


FIG. 36. DIAGRAM OF CONNECTIONS FOR GENERAL ELECTRIC STANDARD VARIABLE SPEED TYPE R I MOTORS

$$\text{Two-hour overload current} = \frac{\text{Kilowatt output} \times 1000 \times 1.25}{\text{Volts} \times \text{Efficiency} \times \text{Power Factor} \times \text{Constant}}$$

These formulas are based on overloads of 25 per cent for one or 2 hours. If motors are guaranteed for 50 per cent overloads, multiply by 1.5 instead of by 1.25.

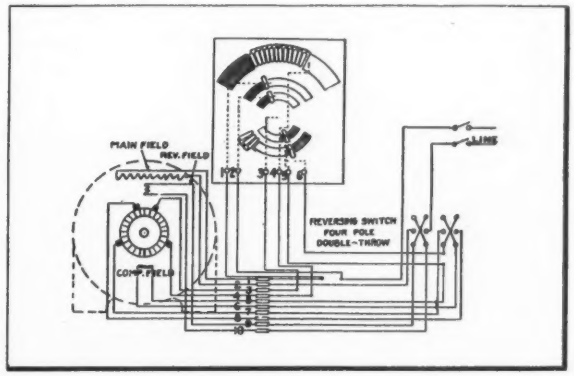


FIG. 37. DIAGRAM OF CONNECTIONS FOR REVERSING GENERAL ELECTRIC VARIABLE SPEED R I MOTORS

Power Factor = 1— for D.C. motors

Constant = 1— for D.C. motors
1— for single-phase motors
2— for 2-phase motors
1.732 for 3-phase motors.

If the actual efficiences and power factors of the motors to be controlled are not known, the following approximations may be used:

Efficiencies

D.c. motors, 35 hp. and less.....0.80 to 0.85
D.c. motors, above 35 hp.....0.85 to 0.90
Synchronous motors (at 100% power factor) .....0.92 to 0.95

"Apparent" Efficiencies (=Efficiency × Power Factor)

3-phase induction motors, 25 hp. and less..0.70
3-phase induction motors, above 25 hp....0.80

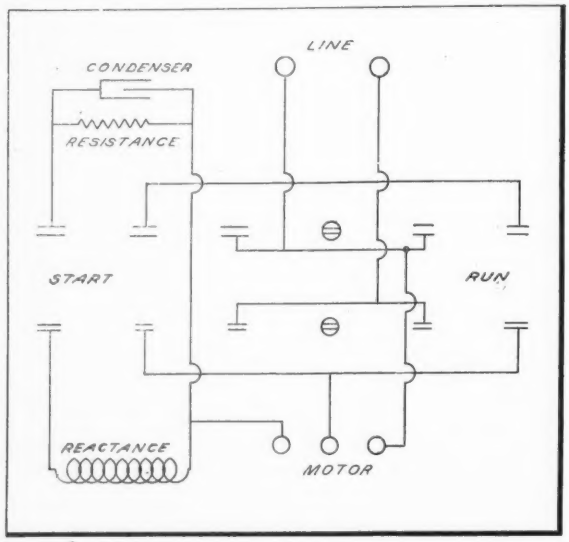


FIG. 38. CONNECTIONS OF A SINGLE-PHASE MOTOR WITH 3-PHASE WINDING

These figures may be decreased slightly for single-phase and 2-phase induction motors.

Single-pole or double-pole overload circuit breakers should be used for protecting direct current motors.

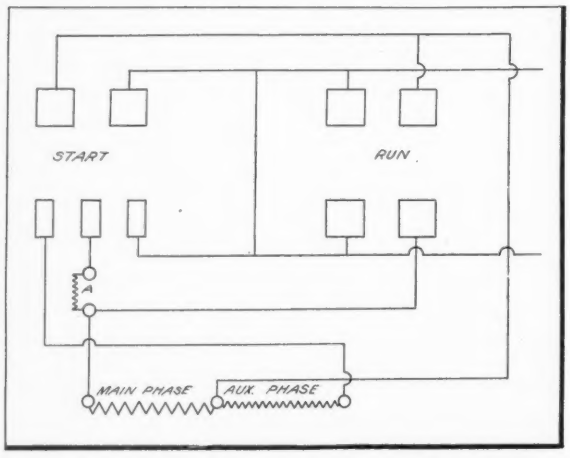


FIG. 39. CONNECTIONS FOR STARTING SINGLE-PHASE MOTORS WITH A 2-PHASE WINDING AND RESISTANCE A IN SERIES WITH MAIN PHASE AT STARTING

Low voltage coils should be provided either on the breakers or starting rheostat switches, to cut off the motor if the source of power fails and for use with speed limiting devices when furnished.

General Electric Repulsion Induction Motor

LEADING characteristics of the direct-current series wound motor operating through a wide range of speed and torque, are well known. This type has, however, no inherent speed regulation and its use is

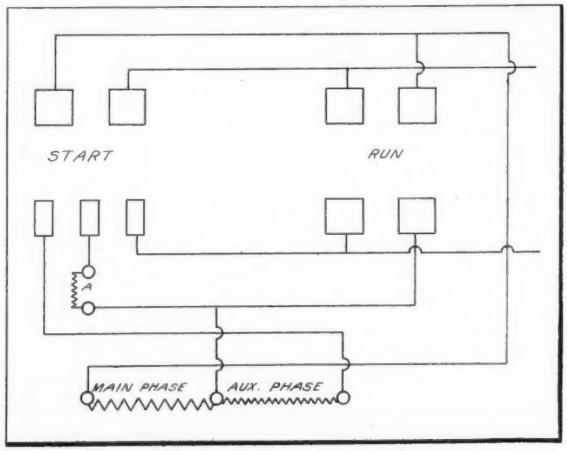


FIG. 40. CONNECTIONS FOR STARTING SINGLE-PHASE MOTOR, TWO-PHASE WINDING AND RESISTANCE A IN PARALLEL WITH THE AUXILIARY PHASE

consequently confined either to fixed loads like fans or pressure blowers, or to varying loads where the motor controlling device is constantly under the operator's guidance. The speed, torque and load characteristics of the commutator series alternating-current motor is distinctly analagous to that of its direct-current prototype, and this design therefore fails to meet the requirements of constant speed service; this service demanding a motor that will maintain good

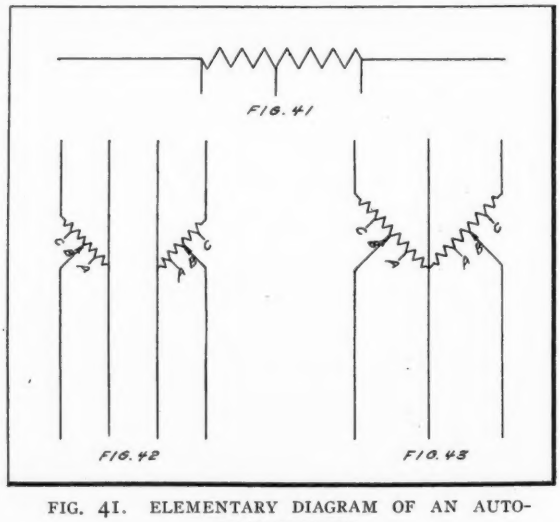


FIG. 41. ELEMENTARY DIAGRAM OF AN AUTO-TRANSFORMER

FIG. 42. ELEMENTARY DIAGRAM OF A 2-PHASE AUTO-STARTER OR STARTING COMPENSATOR

FIG. 43. ELEMENTARY DIAGRAM OF A 3-PHASE AUTO-STARTER OR STARTING COMPENSATOR

regulation after having once been brought up to speed, with torque values increasing at satisfactory efficiency as speed decreases. In other words, the characteristics of a motor for constant speed service should approach

those of the direct-current compound motor having the usual proportion of series field winding.

The repulsion induction motor possesses this combination of series and shunt characteristics; namely, a limited speed, with increase of torque with decrease in speed. To secure the necessary starting torque in the straight repulsion motor, a direct-current armature is placed in a magnetic field excited by an alternating current and short circuited through brushes set with a predetermined angular relation to the stator field. To further improve the operating characteristics of the plain repulsion motor, a second set of brushes, viz., the compensating brushes, is placed at 90 electrical deg. from the main short circuiting brushes, or energy brushes.

The compensating field is auxiliary to the main field and impresses upon the armature an electromotive force in angular and time phase with the electromotive force generated by the main field. In addition to correcting phase relation between current and voltage, thus giving approximately unity power factor at full load and power-factors closely approaching unity over a wider range of load, and compensating field serves to restrict the maximum no-load speed; and also permits, where varying speed service is involved,

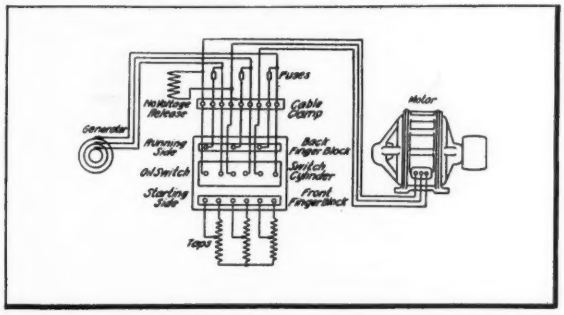


FIG. 44. CONNECTIONS FOR A GENERAL ELECTRIC 3-PHASE STARTING COMPENSATOR

slight increase over synchronous values. The compensated repulsion induction motor is capable of operating either above or below synchronous speed, and possesses heavy starting torque and high power-factor at all loads, as well as excellent efficiency constants.

Figure 33a shows a General Electric repulsion induction motor and Figs. 33b and 33c illustrate its armature and field.

Figures 34 to 37 inclusive, show the internal and external connections of a General Electric repulsion induction motor.

Single-Phase Induction Motors

ONE type of single-phase motor is provided with a winding similar to that of the 3-phase induction motor. The motor is rendered self-starting by means of a starting box containing resistance and reactance and a double-throw switch. The switch is first thrown to the starting position, and when the motor has attained nearly full speed it is quickly thrown into the running position, the object being to first connect the resistance and reactance in circuit with the motor and then disconnect it. The illustration Fig. 38, shows the diagram of connections. Sometimes a condenser is used instead of the resistance. There are a number of designs embodying modifications peculiar to themselves.

In some makes of single-phase motors there are 2 windings, a main winding and an auxiliary winding, where only one resistance is used. The main winding generally occupies 2/3 of the slots, the remaining 1/3 being used for the auxiliary or starting winding. The motor thus starts as an imperfect 2-phase motor. The starting phase generally receives either ½ the number of convolutions of the main phase or twice as many. Figs. 39 and 40, show the connections of such a motor. In Fig. 39 the resistance A, is connected in series with

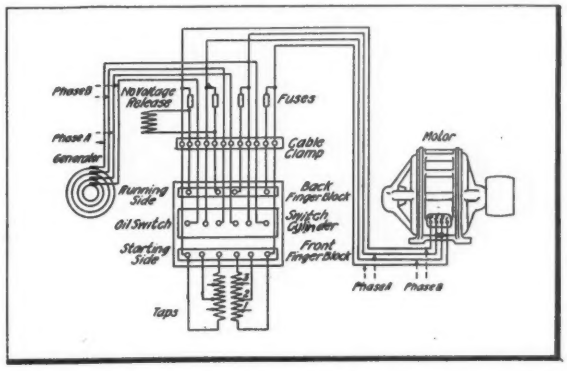


FIG. 45. CONNECTIONS FOR A GENERAL ELECTRIC 2-PHASE STARTING COMPENSATOR

the main phase at starting, the auxiliary phase being directly between the terminals. In Fig. 40 the resistance is parallel with the auxiliary phase which is connected in series with the main phase. During the throwing over of the switch from the starting to the running position, the motor is temporarily disconnected from the line.

Starting 2 and 3-phase Induction Motors

FOR starting 2 or 3-phase induction motors the resistance used for starting direct-current motors is replaced by coils of insulated copper wire wound on laminated iron cores. The coils have several taps as shown in Fig. 41. In 2-phase starters these coils are

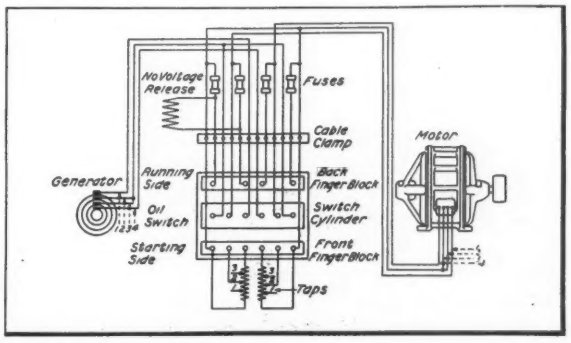


FIG. 46. CONNECTIONS OF GENERAL ELECTRIC 2-PHASE STARTING COMPENSATOR FOR 3-WIRE CIRCUIT

connected one to each phase similar to the primaries of transformers as shown in Fig. 42. As the starting switch is turned, the motor is connected successively to the various taps, each tap reducing the number of turns in circuit with the motor until it is connected directly across the line.

In a 3-phase starter (Fig. 43), the coils are connected between the 3 phases similar to the primaries of 2 transformers connected for 3-phase distribution.

Figs. 44, 45 and 46 show the connections of General Electric compensators for 2 and 3-phase circuits.

Auto starters or compensators can be supplied with special devices to meet various requirements, one being an overload relay for use with standard types; a no-voltage release, similar to that used in connection with the rheostat in a direct current motor, can also be applied to auto-starters or compensators. Auto-starters, or compensators are built for automatic control and may be used to govern the action of pumps and other machines that stop and start as the requirements demand.

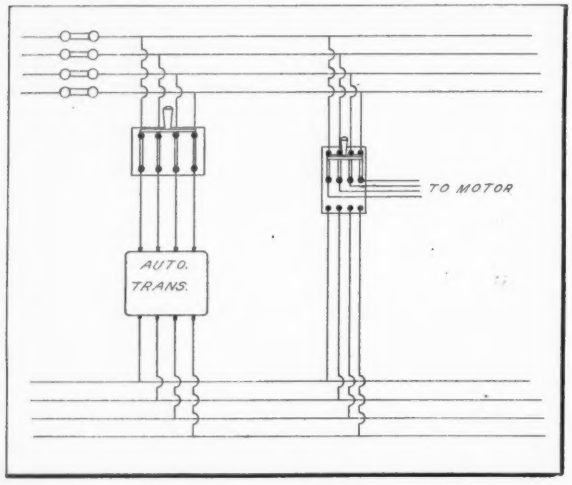


FIG. 47. STARTING SEVERAL INDUCTION MOTORS FROM ONE AUTO-TRANSFORMER

Under some conditions of service it is desirable to start several motors from the same auto-transformer. This may occur when there are several motors grouped in a comparatively small space. Fig. 47 shows the connections of such an arrangement for a 2-phase system. This method is, however, equally applicable to the 3-phase system. To start the motor, the main switch shown over the auto-transformer is first closed. Then the double-throw motor switches are closed in the lower or starting position until the motor accel-

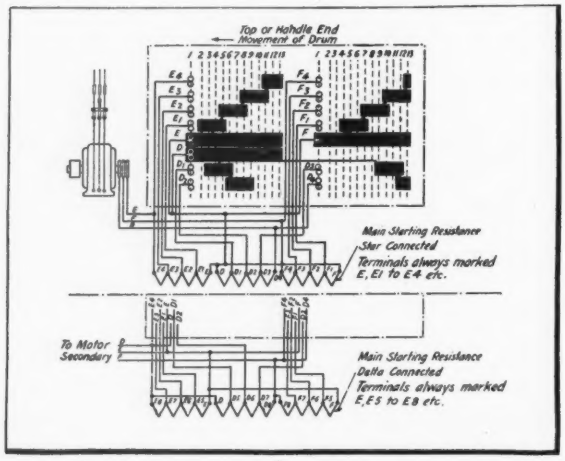


FIG. 48. CONNECTION DIAGRAM OF A WESTINGHOUSE TYPE R. F. CONTROLLER

erates, when they are thrown up to the running position. This operation is repeated for each motor one at a time, after which the main switch is opened. To stop the motors the individual motor switches are opened.

The internal resistance type of induction motor was illustrated and described in the January 15 issue of Practical Engineer.

Figs. 48 and 49 show the connections of the Westinghouse type MF non-reversing starters, for slip-ring alternating-current, constant-speed induction motors of from 5 to 200 hp. The type MF non-reversing starters are used for starting polyphase slip-ring induction motors under light loads where the slip-ring motor is used instead of a squirrel cage motor in

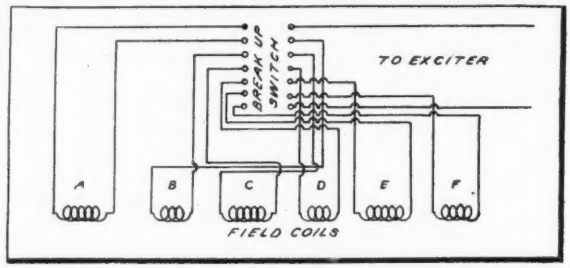


FIG. 50. CONNECTIONS OF BREAK-UP SWITCH FOR USE WITH SYNCHRONOUS MOTORS

order to keep the starting current low. These starters are applicable where the starts are infrequent and the average starting torque does not exceed 1.25 times full load torque.

Synchronous Motors

THERE are several methods of starting synchronous motors. Polyphase currents are almost universally used to supply the application of alternating current directly to the armature without field excitation which will result in a rotating magnetic field about the arma-

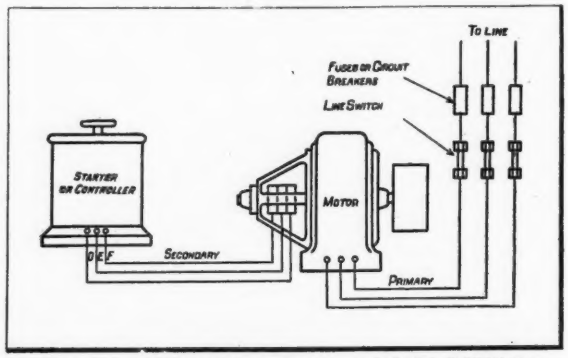
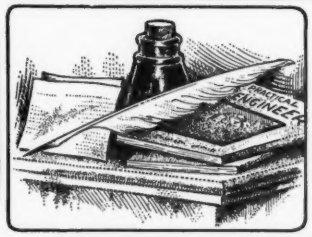


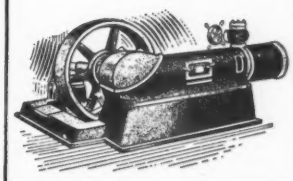
FIG. 49. CONNECTIONS FOR A 3-PHASE EXTERNAL RESISTANCE MOTOR

ture core. The eddy currents thereby produced in the pole faces will exert a torque on the rotor and cause it to speed up to synchronism. Usually a starting compsensator is employed for reducing the applied e.m.f. during the starting period. Under the conditions of starting, the step-up transformer relation between the field and armature winding causes a relatively large e.m.f. to be generated in each field coil. To lessen the danger from this source the windings on the separate poles of a revolving armature type, are insulated from each other so that the e.m.f. generated in the field coils will not be in the normal series relation and thus the total e.m.f. may be limited to the value of that generated in one pole working alone. This is accomplished by a break-up switch as shown in Fig. 50.



Letters from Engineers

Bright Ideas direct from the plant. Send us yours. Cash paid for those accepted. Sketches desirable; we make the drawings



QUICK PUMP REPAIR

I SHOW herewith a manner in which I repaired a broken cylinder head on a small pump we were using. As it was necessary to run this pump quite frequently, to wait for a new head from the factory was out of the question. Figure 1 represents an end and side view

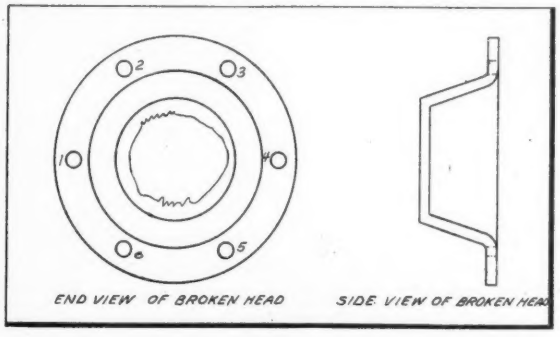


FIG. 1. END AND SIDE VIEW OF BROKEN HEAD

of the head, showing the piece broken out. The studs to hold this head in place were originally all like Nos. 3 and 5 in Fig. 2 at A. I removed studs 1 and 4 and in their places inserted 2 about 3 times as long. I then took a piece of steel ⅛ in. thick, cut it out round and concaved as shown at B, and cut a piece of heavy gasket rubber to fit it.

I then took a piece of heavy strap iron of sufficient length to put the holes in each end to fit over the studs

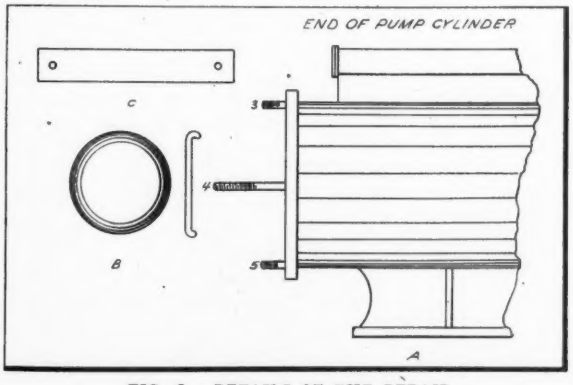


FIG. 2. DETAILS OF THE REPAIR

on the pump; this is shown at C. I took some heavy tar paint and smeared the head and rubber and put the whole thing together as shown in Fig. 3, and I had the pump again when necessary. It took 2 weeks to get a head from the factory.

Thos. M. Sterling.

WATER GAGE SHOWING HIGH

AS to the inquiry of H. S. I think his theory is correct in regard to the water glass showing a higher water level than really exists when the boiler is forced, as the steam connection is so near to the slot in the dry pipe which is equal to an opening of 15 sq. in., for $0.75 \times 20 = 15$ sq. in. It would therefore seem that the pressure would be somewhat lowered around the end of the steam connection thus allowing the water in the glass to rise higher than would be the case if the pressure at both connections were the same.

It is often urged that a steam gage pipe should never be located near the main steam pipe since it

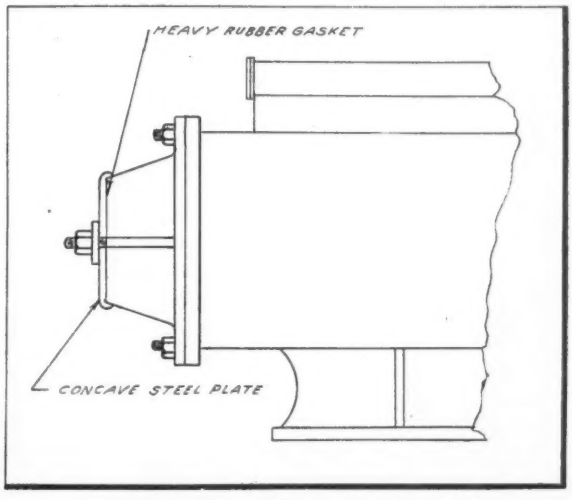


FIG. 3. THE REPAIRED HEAD IN PLACE

may cause the gage to show a lower pressure than exists in the boiler at the time. Why should not this hold true in regard to water column connections as well?

Eddy Current.

UNEVEN BACK PRESSURE ON DIAGRAMS

IN compliance with Mr. Howarth's request in the issue of Jan. 15 in regard to the uneven back pressure, I would suggest that the indicator piping has an air leak at the end where the indicator card shows high back pressure. A small air leak in the piping will cause the pressure to rise and show on the card and yet there will be practically as much vacuum on one end of cylinder as on the other.

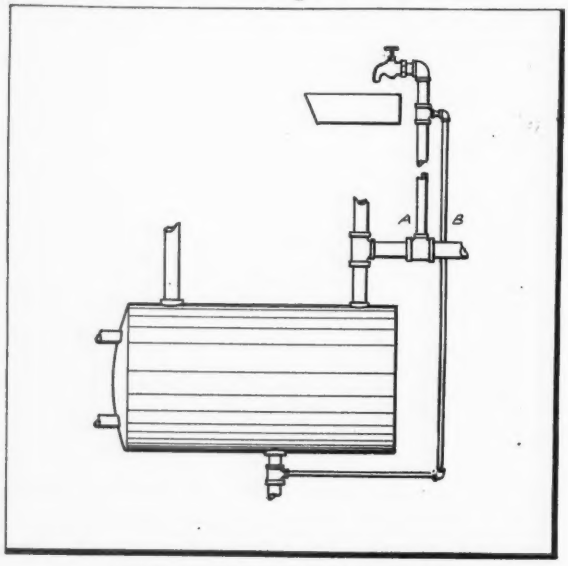
I witnessed the taking of cards from the low-pressure cylinder of a pumping engine which had valves of the poppet type. The cards taken were similar to Mr. Howarth's and at the time they were taken the engineer in charge thought that the valves were not working properly on that end, the engine and valves

appeared to be alright. He then decided that it must be the indicator piping. So the the lagging was taken off the cylinder where pipe is attached and it was found that the nipple between cylinder and elbow was split, which accounted for the back pressure on indicator card. Lawrence Kjerulff.

WATER SAVING

IN city factories and plants where all water is metered and paid for accordingly, the following scheme may be used and considerably reduce the water consumption for washing purposes from 10 to 25 per cent.

A common method of obtaining hot water for the use of the employes is to distribute it from a large tank, heated by a steam coil or by a coal fired tank heater. When "washing up" the water is wasted until it runs hot, the amount lost depending on the distance of the sink or trough from the tank.



HEATER PIPING THAT SAVES WATER

To eliminate this waste, I piped all hot water supply lines as shown in sketch. The supply lines A were practically all ¾-in. pipe and at each faucet I inserted a ¼-in. return line B that went back to the tank, the various return lines entering at the bottom.

In this way a constant slow circulation was obtained, so that when a faucet was opened the water ran hot and was used immediately without waste.

An arrangement of this sort is simple to install, and costs but little, and it will be found to be a paying investment where water is paid for according to the amount consumed. W. Simpson.

PITTING OF BOILERS

I WOULD like to say to my Brother Engineer, whose trouble is explained on page 275 of the March 1st issue, that I have the same kind of plant as he has in charge. I have 2 16 ft. by 40 in. tubular boilers and I use all my return back into the boilers and I had the same trouble as my Brother Engineer has and in 1911 had to shut down my boilers one at a time in the month of March.

I would state first of all, feed water enters at the wrong place, you must put your feed water in at the front of the boiler as you get all the dirt in the blow-off—as there is 18 grains of solid matter per gallon in water. In the second place common soda is not the best thing with which to clean your boiler. In the third place caustic will help your boiler to pit, unless you run the water all out of the boiler the caustic forms a soft small rust on plate and flues of the boiler. In the fourth place, do not use fat oil for your engines as it goes with the steam through the pipes without melting. In the fifth place, use the cheap mineral oils which will cost you 25 or 30 cents per gallon. In the sixth place, when you are not using your boiler, do not let the boiler stand with water in it as it helps to pit the boiler very soon when not in use. Geo. Appleby.

WHY THE GOVERNOR WOULD NOT WORK

I HAD just taken a position as engineer in a small lighting plant in the West and the owner was showing me around the plant, when we got as far as the generating unit the owner said: "The first thing you will have to do will be to overhaul the governor on this engine." I looked the governor over and could not find anything the matter with it and told the owner so. But he stated that when running light the engine would hold the voltage fine but just as soon as the load came on the engine would not hold the voltage, even when all the resistance was cut out of the rheostat.

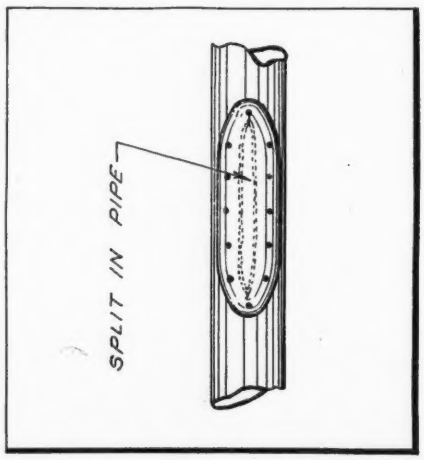
I had a speed indicator with me, so as soon as I could get the plant under steam I started the engine and found that they had the governor set for a speed of over 300 r.p.m. while the rated speed of the engine was 275 r.p.m. Right then I knew the trouble was not in the governor of the engine.

Going to the generator (which was a d. c. machine, 240-V.) and tracing out the wiring I found that they had it connected in such a way that the shunt field was opposing the series field. Reversing the leads to the series field gave me 240 volts and then some, in fact the pilot lamps looked like small arcs even with all the resistance cut in.

After making the above change and reducing the speed of the engine to 275 r.p.m. every thing worked as smooth as silk. Chas. Fenwick.

STAND PIPE REPAIR

ENCLOSED sketch, shows a tower tank stand pipe, that was recently bursted, from allowing water to freeze in it. Also the manner of repairing or patching it.



A HURRY UP JOB ON A BURSTED PIPE

The pipe is 6 in. diameter and had cracked for 18 in. The patch was cut out of a piece of 6-in pipe made hot and swedged down to fit outside of the pipe

over the crack, which had been closed by hammering around it. Not having any patch bolts, we had to use ⅜ by ¾ in. cap screws 2½ in. centers. After placing a rubber gasket between patch and pipe, it was bolted up tight and water turned on 4 hr. after we began the job. The repair proved to be very satisfactory.

A. R. Kansas.

CONSULTING ENGINEER

IN reading over my Practical Engineer of Jan 15th, on page 89 is a talk by Traveler (Wrong use of the Consulting Engineer). Now, I heartily agree with the operating engineer, for he took the plant when it was dow and out and raised it up to where it should be, and then to have the new superintendent, a man who had been handed through the office because he had a pull, being the president's son, ignore the engineer by putting a man over him whom the operating engineer could teach many things, is certainly injustice.

I don't want it to be understood that I have no use for the Consulting Engineer, for in his place he is a necessity. Some time ago I read in a magazine an article written by a consulting engineer who said that the consulting engineer laughs up his sleeve at the mistakes that the operating engineer makes. Such is not always the case, for in 30 yr. of practice as an engineer I have seen some awful blunders made by the consulting engineer that the operating engineer could not possibly make. I have known some operating engineers who were all anyone could wish as an operating engineer, but a complete failure as a consulting engineer. I have also known some operating engineers that, as consulting engineers, were as good as the best, and I have known some consulting engineers that didn't know a coal shovel from an indicator.

Some time ago a circumstance came to my notice of a manufacturing company that had grown so large that the power plant was far too small and the engineer was the first to see it, as he should be. He took the matter up with the superintendent after he had gone over all the ground himself, made all data, found out what he wanted, so when the company took the matter up with him they could not get back at him. After a number of talks with the superintendent, he was asked by the manager all about it, and at the next directors' meeting they voted to put in a new plant. The superintendent asked for and got a consulting engineer, who came to the plant, completely ignoring the operating engineer; came with his assistant and started to take measurements and sketches, but he soon ran across a number of snags and the only way he could get the information was from the operating engineer; but he was plainly told that if the consulting engineer was too good to speak to him except when he wanted information, he must get the information from some other source. As he could not get it from him, he went to the superintendent, and both of them appeared to the engineer and some sharp words passed between the engineer and the superintendent. The engineer told him, as the matter was taken out of his hands and he was not consulted in the matter, he should have nothing to say for or against what was done, and then they could not get back at him; for when the plant was complete, if it didn't suit him, he didn't have to run it.

The manager heard about the misunderstanding and told both the superintendent and the consulting engineer that not a thing should be done or a thing bought unless the operating engineer was satisfied with the arrangements, and the manager told the operating engineer so. But as everything was ordered—engine, boiler, heater, generator, pumps, in fact everything but a few minor things—the operating engineer was not in it.

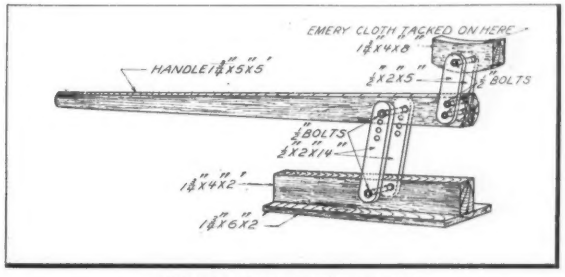
In a few weeks things started to arrive, and then the fun started in earnest, and the operating engineer would not have any interference in running the old plant and he kept it going night and day, and did not shut down a minute. But if he had given in to the consulting engineer there would have been more than one shut down. When the new plant was put to work it was found to be too small to do the work; it was then that the operating engineer could laugh up his sleeve at the mistake that was made by the consulting engineer. Now, in my opinion, if that consulting engineer had talked the matter over with the operating engineer, the company would have had a different plant.

ENGINE JACK; CORRECTION

I WAS looking over my paper and in the article Boiler Heating Surface and Engine Horsepower, page 269, March 1st issue, there is a mistake in figuring the heating surface of a boiler tube.

It should read $18 \times 60 \times 1.047 = 1130.7$ sq. ft. instead of $18 \times 60 \times 1.047 = 1081$ sq. ft. It makes a difference of 49.7 sq. ft.

I have a jack with which I turn my engine off center, that works very nicely and may help some other



HOME-MADE ENGINE JACK

engineer out. The handle is good hickory 5 ft. long, 5 in. wide and 1¾ in. thick. The base 2 ft. long, 1¾ in. thick and a board nailed on the bottom 6 in. wide and 2 ft. long. The irons are ½ by 2 in. 2 of them are 14 in. long, the other 2 are 5 in. The block that fits the balance wheel has a piece of emery cloth tacked to it, and is 1¾ in. thick, 4 in. wide and 8 in. long. ½-in. bolts are used to put it together.

B. A. Held.

REGULATING AMMONIA LIQUOR STRENGTH

IN Practical Engineer for February 1st is a paragraph from Ice giving proper credit, this was in an answer to a query from a subscriber asking for information as to how to reduce or increase the strength of his charge of aqua ammonia in an absorption system. Mr. Lukenbach offers a criticism of this answer in the March 1st, issue page 260. As he did not evidently have an opportunity to compare the answer with the query, I do not wonder at the criticism being made.

As the answer was intended to be specific, however, and in response to a definite inquiry as to how to do these things I consider that the answer was correct, in that it stated how these things should be done.

Wm. Westerfield.

DEFECT IN OHIO LICENSE LAW

MR. Jones, in the March 1st issue, asks why the engineers on steam rollers, hoisting engines, etc., are not required to have a license in Ohio. The reason is in the defect of the Ohio license law, which says in substance, "all boilers over 30 hp. rating shall re-

quire a licensed engineer"—this does not include street rollers, hoisting engines, agricultural engines, stone channeling machines and many other small boilers which carry often times 140 or 160 lb. pressure because they are less than 30 hp. and as Mr. Jones says: are frequently in charge of men who are not competent to care for them.

About 2 years ago the writer, who was at that time a resident of Ohio, was appointed by local 307 I. U. S. E. as one of a committee to draft an amendment to the existing state license law and get it in the hands of the state legislature. The measure while open to improvement stated that all boilers carrying over 25 lb. pressure per sq. in. (locomotive and boilers under the jurisdiction of the U. S. excepted) regardless of size or capacity should require a licensed attendant and the steam-pressure carried as well as the capacity of the plant to determine the grade of license required to operate the plant.

The measure was turned down by the members of the legislature in favor of one, which I believe was gotten up by the boiler makers, and which required state inspection of boilers at regular intervals independant of the insurance inspections and which was to cost the boiler owner $5 per boiler for each inspection; the state inspector having power to shut down any boilers deemed unsafe until repaired, etc.

This measure failed to pass the legislature for some reason and the law is now about as it was in the beginning. At the present time there is no state inspection that I am aware of and any boiler of less than 30 rated hp. may be lawfully operated by any one who can get the job and even in plants that come under the jurisdiction of the license law, an engineer with a 3rd class license can lawfully operate any power plant in the state regardless of size. As the plants are not classified while the engineer is. J. C. Hawkins.

RECEIVER EFFECT ON DIAGRAM

THE accompanying set of indicator cards which came from a cross compound engine have a peculiarity which we do not often run across. We have noticed in the past some inquiries from readers of technical

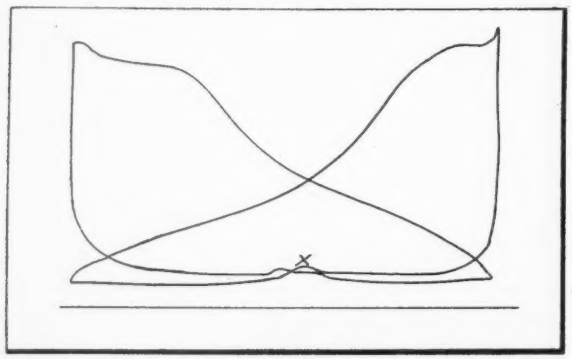


FIG. 1. HIGH-PRESSURE CARD WITH DEFECTIVE ATMOSPHERIC LINE

journals as to this peculiarity, and it seemed to stand without an answer, and as we have here a nice example, we shall endeavor to make the matter plain. Number 1 card is the card from the high-pressure cylinder, steam pressure 150 lb.. The jump in the atmospheric line is clearly set out at X; at this point the pressure rises and is caused by the closing of the steam valve on the low-pressure side, and is caused by the receiver being too small. This is a fault that we run across sometimes and cannot remedy by the valve setting. The low-pressure card is shown in No. 2, which shows a fairly good setting. Card No. 3 shows a single card and makes the rise in the back-pressure line clear, which occurs just at the point of closure on the low-pressure side of the engine. While this does

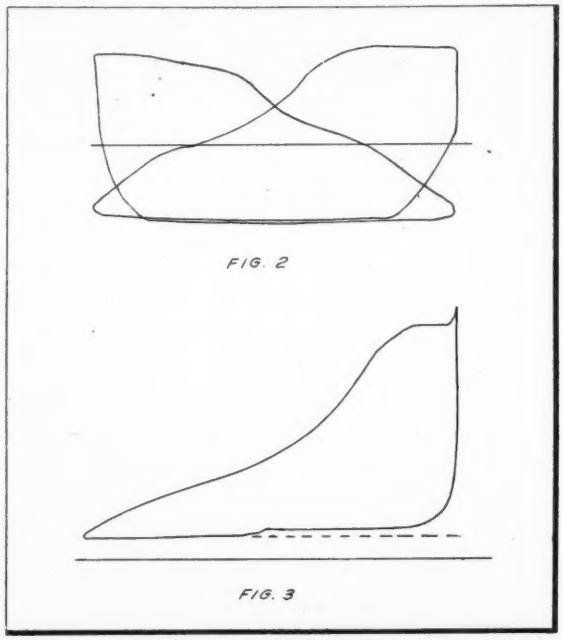


FIG. 2. LOW-PRESSURE CARD FROM COMPOUND ENGINE
FIG. 3. HIGH-PRESSURE CARD SHOWING EFFECT OF TOO SMALL RECEIVER

not affect the economy of the engine materially the engine would work better with a receiver of the proper size, while a receiver too large will cause a loss as well as one too small. Cards coming from compound engines are frequently affected by the low-pressure side just as in this example. C. R. McGahey.

CLEANING OF PRODUCER GAS

THIS is one of the problems confronting the user of this gas especially when it is used for power purposes.

We have had a little experience with this gas both for power and small furnace work, the latter requires a clean gas as well as in power work on account of having to pipe the gas cold and in small quantities.

It has always been a question in my mind why the promoters of fuel gas projects gave so little heed to the methods of the illuminating gas people who turn out a clean product by well tried methods.

They seem content to find their own way without trying to profit by the experience of others.

The result is crude and unsatisfactory working plants, retarding the progress of an economy in the use of one of the necessities of life.

Most of the users seem to have trouble only with the dust in their gas. We never see any trace of dust but do have to look out for tar. I don't understand how they make gas from soft coal and are troubled only with the dust. Our tar troubles have not been bad enough to interfere with operation, nor increase the cost by a noticeable amount.

We have the ordinary up draft type of producer a cooler with water spray apparatus in the top against which the gas rises to a rotary washer of German

make, thence through a dry scrubber. Also on the engine line we have an auxiliary filter which removes quite a little of the tar which passes through the cleaning apparatus without being condensed or otherwise removed. We make a gas of 140 to 150 B.t.u., which works well in the engine and gives a temperature of 2300 or 2400 deg. F. in the furnaces.

Much effort and money has been spent in trying to burn or convert the tar into a fixed gas by means of double zone producers without, so far as we have been able to learn, much success. From our experience with ordinary producers we are of the opinion that the conditions necessary to produce a good and tarless gas could not be maintained in a double zone producer for any length of time.

As you reduce the amount of tar you increase the amount of lampblack and vice versa one of the evils you will always have with you, and some gas engineers think the tar is easiest to handle. A high temperature in the producer means lampblack, a low temperature tar, this refers of course only to gas from soft coal.

We believe the cleaning of this kind of gas will be much simplified as well as better results secured as the problem comes more into the hands of practical engineers, who will gradually overcome the obstacles left in the way by the designers of the apparatus.

When an engine can be run 16 months without the piston rings sticking in their groves it shows the gas is fairly clean, we were never able to do better than this with natural gas, seldom as well. The oil fed into the cylinders will cause some trouble even if the gas is absolutely clean.

We should judge that about 20 per cent of the heat value of the gas was scrubbed out of it in cleaning, 20 per cent more lost in sensible heat and probably another 20 per cent loss in the producer. We see that the combined efficiency is not high.

Water vapor is another evil we have to contend with especially if we send the gas into the mains at a temperature above 70 deg. F., which we must do or the tar will clog up the rotary washer. S. E.

REPAIR JOB ON A PUMP

THE pump was used for a boiler feed pump and was a 12 by 9 by 14 in. of the pot valve, center-packed type; the gland was cracked as shown by Fig. 1, and as

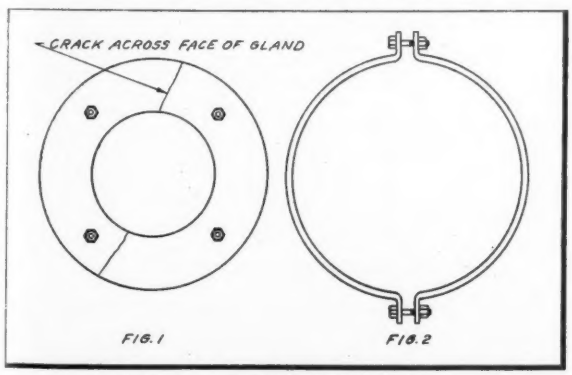


FIG. 1. CRACKED PUMP GLAND
FIG. 2. CLAMP FOR FLANGE

a new gland could not be procured in less than 2 weeks, and the pump was needed for the peak load, I made the following repair.

I got some ¼ by 1-in stock and made a strap to go on the outside of the flange as shown by Fig. 2. By drawing up on the bolts the gland was held together. Then I made 2 clamps as shown by Fig. 3. The stock was ⅜ by 1¼ in. and I drilled a 13/16-in hole in each end so that the clamps would slip over the studs. I fitted them on the top and bottom studs, this enabled us to set up on the packing and prevent any leakage. Figure 4 shows the job completed, and proved satisfactory until a new gland arrived.

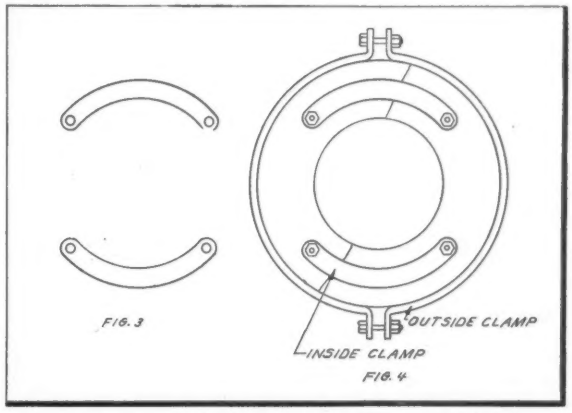


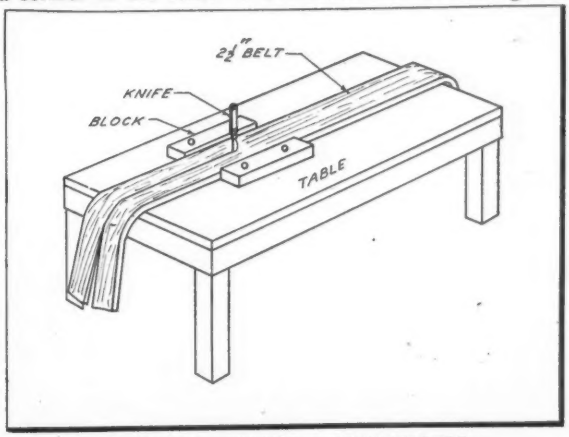
FIG. 3. CLAMPS USED ON FACE OF GLAND
FIG. 4. PUMP GLAND SHOWING REPAIR

In packing pumps of this type care should be taken that all the old packing is taken out and that the plunger is central in the stuffing box; if the plunger sags and the clearance is greater at the top a small jackscrew placed under the rod or plunger will center it. I find by soaking the packing over night in oil and cutting it ⅛ of an inch short it gives better results.

John J. Mahoney.

CUTTING A BELT

IN our power plant we had to cut a belt so that we could get a piece 1¼ in. wide, having none in stock, we took the following method of doing it. On a 2½ in. belt we drew a line with a square and then set a scriber to the center and marked the line through the



METHOD OF CUTTING A NARROW BELT

center of the belt. We then attached 2 boards to the bench so that the 2½ in. belt would just slide between them, and set a knife to come exactly at the line at the center of the belt. The belt was then pulled along between the 2 boards, taking care that it was moved so that the knife always followed the center line, and in this way a true and perfect edge was secured.

Questions and Answers

To help you when in trouble; give name and address. If quick answer is wanted, enclose a stamp for reply.

Three-phase Problem

HOW would you figure the total output in amperage and the wattage of a 3-phase generator having three ammeters at switchboard; for example, at 2300 volts and ammeters reading 10 amperes, 7 amperes and 4 amperes, respectively?

A. If the armature is Y connected as shown in Fig. 1, the voltage in each phase of the winding would be 2300, which you give as your line voltage, divided by 1.732=1326 approximately.

The current generated in the armature equals the line current. If your ammeters read as given the instantaneous line current equals 10+7+4=21 amperes.

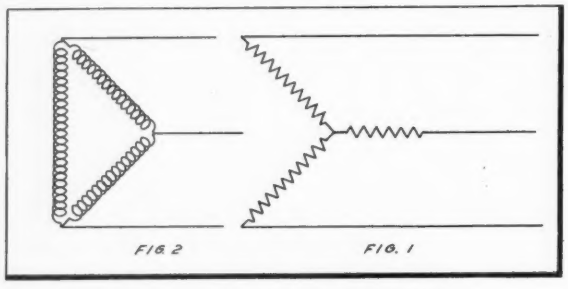


FIG. 1. Y OR STAR CONNECTIONS
FIG. 2. DELTA CONNECTIONS

The watts output would then equal 1.732×(2300×21)=83,559 or 83.5 k.w. approximately.

If delta connected as shown in Fig. 2, the voltage of the line is equal to that of each phase of the winding. The line current is equal to the current in each phase times square root of 3 or 1.732=

$$\left.\begin{aligned} 10\times1.732&=17.32\\ 7\times1.732&=12.12\\ 4\times1.732&=\ 6.92 \end{aligned}\right\}=36.36$$

The output in watts would equal to, square root of 3 or 1.732×(2300×26.36)=144.845 watts, or approximately 145 kw.

These conditions are true only when the load is non-inductive. When an inductive load is carried the power factor has to be taken into consideration.

Mean Effective Pressure

WILL you explain how to figure the m.e.p. of enclosed card, as I do not understand figuring vacuum card? L. E.

A. If you use a planimeter, proceed as you would with any card—there is no difference.

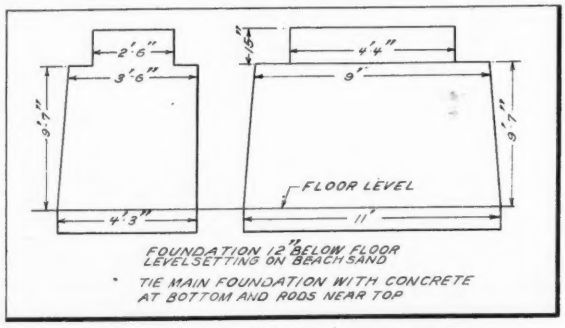
When using the graphical method of obtaining the m.e.p., the only difference is that you will reckon the lengths of ordinates from the vacuum line instead of from the atmospheric line, which will be placed below the atmospheric line a distance equal to 14.7 lb. measured by the scale of the spring used.

With a 12 lb. spring this distance would be $\frac{14.7}{12}\times 1$ or 1.22 inches. The atmospheric line then has nothing further to do with the card except to give the length.

Outboard Bearing Foundation

MY engine is a 22 by 44 in. Hamilton Corliss, 76 r.p.m. Enclosed is sketch of outboard bearing which rocks back and forth. How can I steady it without a shut down? Floor level is only 6 ft. from sea level. W. F. B.

A. In the outboard bearing foundation, as you show it, there is only the static momentum of the mass to resist the thrust of the piston, that is, the bracing effect, which would prevail were the foundation set in an excavation in solid earth, is absent.



EVOLUTION OF ENGINE FOUNDATION

The only remedy appears to be the addition of considerable weight to the foundation, placing it parallel to the length of the engine, and binding it to the old part to form a homogeneous, or solid mass. In adding concrete to the present foundation, it is hardly possible that a joint could be made, due to the rocking, providing it were attempted without a shut-down.

If it were possible to drive a few piles into the sand where the new concrete is to set, allowing the piling to protrude a foot or so into the concrete, a firm foundation should readily to be obtained.

Greene Engine Questions

IN regard to questions about the Green Engine, which appeared in the March 1 number of Practical Engineer, it seems that question 3 was not clear. In the cut the lower ends of the tappets G and G^1 have a round section, which move easily up and down in vertical round holes in the sliding bar.

The round section of the head end tappet is about 1/16 in. longer than the one on the crank end and when the governor rod is unhooked the square section on top of the crank end tappet rests on the bottom of the

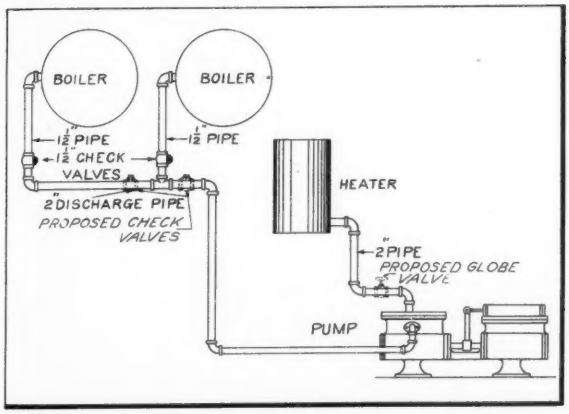
slot in sliding bar, while the head end tappet seeks a position 1/16 in. above the bottom of its slot, which is due to its being a little longer.

The question was, why are these tappets of different lengths?

These tappets are numbered 1 and 2, and correspond to 1 and 2 on the sliding bar so that they may not be put in wrong. J. W. Collins.

Feed Water Pump Problem; Pounding of Check Valves

IN March 1 of Practical Engineer, on page 270, E. J. W. writes of pump trouble he is experiencing. I should advise him to make a few tests. 1. The rings in the steam cylinder may be too tight and the cylinder rough from boring out. By feeding the lubricator quite fast for a few minutes it could be determined whether or not there is any trouble of that kind. 2. Remove the head on the water cylinder and with a swab and dry graphite give the cylinder walls a good coating while running the pump slow, this will tell whether or not the packing is tight. This test should be made with suction and discharge valves closed. The rocker arms may have too much play in the crosshead, due to wear, which would prevent the steam port from opening far enough. Ports should be wide open when piston starts the stroke.



PROPOSED CHANGE IN LOCATION OF CHECK VALVES

In the same issue, N. F. S. gives some trouble he is having with pounding check valves. A vertical check valve will always give more or less trouble of this kind when the water cylinder is newly packed. I should advise him to remove them and put a globe or gate valve in their place and use horizontal swing checks, which are practically noiseless, and place them where shown in the sketch, also place a gate valve in the suction line as indicated, so the water may be shut off to repair the pump when needed. Geo. H. Worth.

Condenser Trouble

WE have just installed in our plant a 10 in. by 12 in. by 13 in. Deane jet condenser and are unable to get over 26 in. of vacuum. We have a 6-in. main connecting the condensers with the lake, which is generally straight and gives the condenser a lift of 16 ft. It pumps water allright, but if the injection valve is closed to raise the vacuum it looses all we get. All of the pipes have been examined; there are no leaks.

We can run the engine about five minutes or so, then it looses the vacuum. Do you consider that entrained air is the cause of the trouble? E. M.

A. With a lift of 20 ft. and the very long suction pipe, a vacuum of 26 in. may be considered good. It is not understood how you hoped to increase the vacuum by closing the injection valve. For a few moments after the injection valve is closed, the exhaust steam meeting the cool metal of the condenser will, of course, condense to a greater degree. This, combined with the action of the pump, will, in all

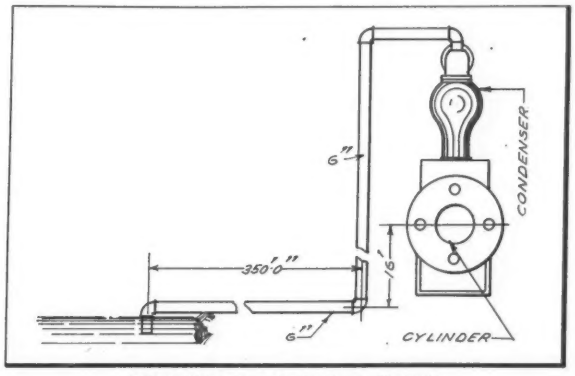


DIAGRAM OF CONDENSER PIPING

probability, maintain a constantly decreasing vacuum, which ceases altogether in a few minutes, or as soon as the condenser walls are heated to the temperature of the exhaust steam. When this happens, the low pressure cylinder is practically discharging directly into the pump cylinder, which, being very small compared to the l. p. cylinder, is unable to discharge the exhaust steam as fast as it is recorded. The condenser, then, naturally fills with the exhaust steam or vapor, destroying the vacuum.

It would undoubtedly have been admissible to have used an 8-in. pipe in the suction line, 350 ft. being a fairly long pull. The 20 ft. lift (the distance from the cylinder to the top of the condenser must be taken into account) is also high and imposes a large burden on the pump. It is always well to set the condenser as low as possible relative to the level of the supply.

The temperature of the supply is also important. If its temperature were not over 70 deg. F. you might obtain a 28 in. vacuum under most favorable conditions, but hardly with such a long suction and its exposure to the sun's rays, and the high lift.

To avoid all air pockets or summits in the suction line, it is advisable to grade the pipe towards the source of supply—in a length of 300 ft., not less than 4 ft. fall should be allowed. Such a grade should be laid out accurately by a civil engineer or one who can accurately use a level.

If you are certain there are no leaks, and valves, piston, etc., are tight, a better vacuum than 26 in. can hardly be hoped for.

Grading the line could be done without interrupting the service, but it would only prevent the possibility of any air pockets forming. On long suctions it is also well to install a suction air chamber.

VALVE QUESTIONS

HOW do you give an engine clearance?

2. If a valve has 9 inches travel, 2¼ in. steam lap, ⅛ in. lead and 3/16 in. lap on the exhaust, to what extent would the exhaust port be open when the piston is at the end of its stroke?

3. If a piston of an engine has 45 in. stroke and

the valve had 6 in. travel, 2 in. steam lap, ¼ in. lead, how many inches would the piston travel when cutoff occurs? D. J. H.

A. 1. You can't alter the engine clearance. It is the space in the cylinder, in excess of the piston displacement, and is a quantity fixed when the engine is designed and built.

2. Fig. 1 shows the valve in mid position; Fig. 2 shows the valve when piston is at end of its stroke. The valve travel does not enter into the solution but the width of ports might, so a part 2 in. wide is assumed.

At the end of the stroke, let us say, at the beginning

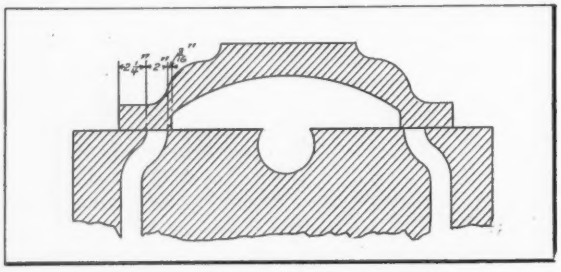


FIG. 1. VALVE IN MID POSITION

of the stroke, a valve has moved ahead of the piston so that the port is open by an amount designated by the lead,—in this case ⅛ in. Therefore, if the valve has 2¼ in. steam lap, it must have moved, when piston is at beginning of stroke, 2¼ in. + ⅛ in. or 2⅜ in. Consequently, if the port is 2 in. wide, and there is 3/16 in. exhaust lap, the port on the crank end would be wide open when the valve had moved 2 in.+3/16 in. or 2 3/16 in. But to give the ⅛ in. lead on head end the valve has moved 2⅜ in. from mid position, therefore the inside or exhaust edge of valve, on crank end, has passed beyond the edge of the port 2⅜ in.—2 3/16 in. or 3/16 of an inch.

3. In Fig. 3, P P′ represents the piston travel 45

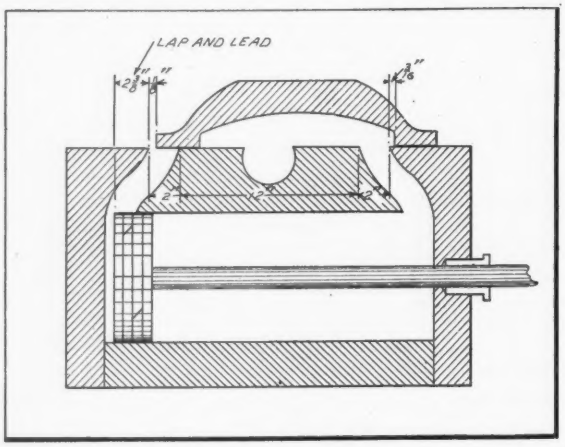


FIG. 2. VALVE POSITION WHEN PISTON IS AT THE END OF ITS STROKE

in. and P F P′ the crank pin circle.

V V′ is the valve travel, 6 in. and Vâ V′ the eccentric circle.

E and C are the eccentric and connecting rods, respectively.

When connecting rod is on head end dead center it is in the position C, and the crank pin is at P. If there were no lap or lead, the valve would then be in mid position, as shown at a on the valve circle; a slight movement then, would open the valve admitting steam to the head end of piston, and the valve port would be open until the valve had completed its travel at V′ and come half way back at a′. The angle between the crank pin and eccentric is constant; with the crank pin at P, the eccentric is ahead of it by the angle V o a.

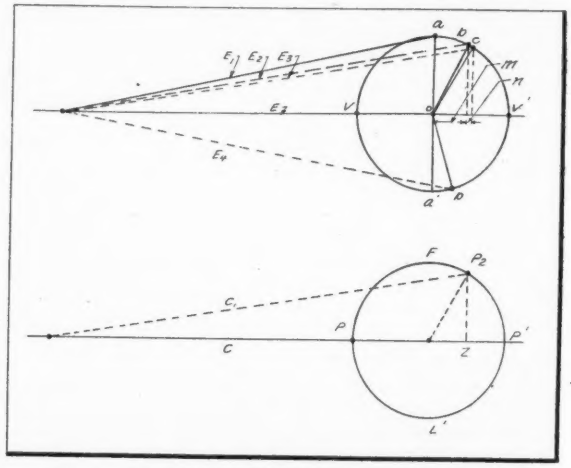


FIG. 3. DIAGRAMS SHOWING EVOLUTION OF VALVE MOVEMENTS

Therefore, when the eccentric moves from a to a′, 180 deg., the crank pin has gone 180 deg. or to P′, showing that steam has been admitted the whole stroke.

To overcome this, we add lap; in this case 2 in. Therefore, with piston on head and center, the eccentric is moved ahead a distance of 2 in., represented by m, and eccentric rod is standing at E_2. Now moving ahead the ¼ in. lead on m in a similar manner, the eccentric rod is now at E_3, with the crank pin at P. When the eccentric is a b, or the eccentric rod at E_2, the valve is line and line with the head end port and just about to open. By shifting its position to b′ or E_4, it is again in the same position, only it is about to close. Therefore, cutoff will occur when the eccentric has moved around to b′ or E_4.

With piston or crank pin on center, the valve was open by the amount of the lead, or the eccentric was ahead of the crank by the angle V o c. Since the eccentric travels from C to b′ it has passed through the angle c o b′. Therefore, the crank pin has moved from dead center P, through an angle to c o b′, and is now at P_2 when the eccentric is at b′ where cutoff occurs.

Drop the line P_2 Z from P_2 and measure P Z. Supposing P P′ had been drawn 8 in. long and P Z measured 5 in., then the piston would have moved ⅝ by 45 or 28⅛ in.

The piston diagram need not be drawn to scale, as here shown, but the valve diagram must.

Without lead the angle would be b o b′ instead of c o b′, which you will readily understand.

KENTUCKY NO. 1 NATIONAL ASSOCIATION STATIONARY OF ENGINEERS held an open meeting, Wednesday night, March 20, in Odd Fellows' Hall, at which time J. F. Davis, district sales manager of the Oil City Boiler Works, gave a lecture on the Geary Water Tube Boiler which was illustrated by stereoptican views. Members of the Association were requested to bring their employers.

Problems for Discussion

What Would You Do Under These Conditions?

Unusual Pumping Station Accident

IN regard to the problem entitled "Unusual Pumping Station Accident" in Feb. 1 issue of Practical Engineer; the only way I can account for such an accident is that when the engine was shut down for 15 min. the vacuum was not broken and the injection water to condenser was not shut off. The engine was probably about in the position as shown in Figs. 1 or 6 with the left-hand crank 90 deg. behind the right hand crank, so that the exhaust valves on the head end of both low-pressure cylinders were open.

Steam that was in the cylinders when the engine was shut down condensed and created a vacuum, this caused the injection water to rise through the open exhaust valves into the cylinder to an extent the vacuum would sustain. In describing the accident it was not stated if the pump raised the water by suction or flowed into it. I assume that it had to be raised by suction, and when the engine was stopped the pump became partially empty on account of the suction valves leaking.

If the engine was given a good charge of steam, with little resistance in the water end, it would start with a jump. Judging from the distance that each rod was driven through its piston the right-hand low pressure piston was the first one to receive the strain. When the engine was started the head-end exhaust valve of right-hand low-pressure cylinder closed, confining the water between the head end and piston. The force of steam in the head end of the left-hand high-pressure cylinder together with the inertia of the flywheel drove the rod through the piston 1⅜ in. and caused the other damage. At the same time it forced part of the water that was confined, through the opening of the intermediate valve into the high pressure cylinder condensing the steam.

As the engine revolved it took steam in the right-hand high-pressure crank end. The left hand low-pressure head-end exhaust valve closed confining the water, driving the piston rod ⅜ in. into the piston in the same manner as in the right hand low-pressure cylinder. Steam next entered crank end of the left-hand high-pressure cylinder and as the return stroke was about to be completed in high-pressure cylinder on the right-hand side, the intermediate valve closed confining the water between the head and piston.

The connecting rod buckled by the force of the steam in the left-hand high-pressure crank end of cylinder and the inertia of flywheel as the left hand high-pressure piston was completing the return stroke. The intermediate valve on head end closed trapping some of the water between the piston and head end. The piston rod was driven into the piston less than in the right-hand high-pressure cylinder.

If it had been water in the steam pipe, the engine would have started slower and with less force than it would with steam. L. K.

Solution of Expansion Bends in Pipe Lines

AFTER reading problem in Mar. issue of Practical Engineer I am inclined to think the makers are right, and that there is not sufficient provision made for expansion. The questioner estimates that there is 11 in. expansion, and if that is so then the bends do not seem enough, for, in the first place, in the arrangement shown the work will not be anything like equal. It would be interesting to know the exact movement taking place, but I think it will be somewhat as follows:

On warming up, the pipes will lengthen out and should close the bends; but it is likely enough that the one between the branches will not close much, for these are a good length, and unless held tightly, will spring and ease the bend, but the other bend has two-thirds of the pipe to reckon with, and one end of pipe fast at boilers, and the resistance of branches at the other, which, although not great, is not to be neglected. The movement on this bend must be something like 7 in, and if the bend is only 2 ft. long, it certainly is not enough, and I wonder it did not break sooner. Recently, where I am employed, two new boilers were coupled together by a 2-in. pipe for auxiliary purposes; they are 11 ft. centers, and a bend 1 ft. 9 in. was made from best quality mild-steel pipe, and when hot, the expansion, instead of closing the bend, lifted the pipes in the center, so that they sloped from center to stand pipes, but on cooling they opened the bend without returning to the horizontal, showing that the bend offered more resistance to closing than opening, and this is worth noticing, for it probably explains why the bend broke, and I suggest that in expanding the pipes "buckled" somewhere in the line and so adjusted themselves to the conditions, but in cooling they shortened, and the bend not being equal to the strain broke before pipe would straighten out. The quality of the material may have something to do with it, and if only ordinary wrought-iron pipe was used then it may be poor, for such pipes often are. I would adive the questioner to put in two bends with at least 4 ft. centers, and see to it that they are the best quality of mild steel to be obtained and from experience of hundreds of expansion bends and joints, I hold that the horse-shoe shape is not satisfactory, but should be in the shape of two letter S's facing each other, and it seems reasonable to expect the bend to be strongest when in compression, for then outer radius is in tension and the shorter inner radius in compression, while if the bend is being pulled open the reverse is the case, and the leverage is increased by diameter of pipe. In conclusion, my advice to the questioner is, put in enough to start; it is just as cheap to buy two together as it is to get them in two instalments. H. J. H.

DON'T BLAME the man that is always talking shop for he is not talking about his acquaintances.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Joint Meeting with the American Boiler Supply Men's Association at New Orleans, Mar. 12 to 15.

OPENING UNDER THE most favorable auspices, after a rain which cleared and cooled the air, the meeting enjoyed the best of climate, entertainment and conveniences that New Orleans with its famous hospitality could furnish. A good attendance, cordiality and enthusiasm among all present, a fund of good papers and a live and worthy object gave abundant reason for success—and it came.

New Orleans has been taking a far look ahead, and though handicapped by circumstances of material situation and financial heritage, has been making provision for securing to its citizens and to those of the state and nation all the natural advantage of its position and a great harbor owned by the city, and the created advantage of a public belt railroad connecting and giving access to all lines of ships and railroads that enter the city.

Mayor Martin Behrman told something of this and of the other advantages which the city has to offer to manufacturers in his address of welcome on Tuesday morning, when he welcomed the convention so graciously that all felt the charm of his hospitality and became at home at once. He traced something of the engineering interest of the great sewage and drainage and water supply systems, something of the historic interest of the old landmarks, and closed with the wish that trains might always be on time in arriving and late in departing so as to give visitors more time in the city, and that the convention might be an unqualified success.

One of the late trains delayed President E. D. Meier, and in his place W. H. S. Bateman of Philadelphia, thanked his Honor for the welcome, complimented the city on the hospitality that it always extended and assured Mayor Behrman that the members and ladies could not possibly do otherwise than enjoy their stay in the Crescent City.

Mr. John A. Murphy of New Orleans, seconded the welcome to the city, particularly as the convention had been brought to him, so the officers said, "because he could not be taken to the convention."

At this time Col. Meier arrived and was heartily greeted, taking the chair which Secretary J. D. Farasey had filled up to that time. President Meier introduced Mr. James W. Porch, president of the Progressive Union, the man and the organization which have done the work of conserving the city's resources to its people, and pushing the great public undertakings to success. Mr. Porch told a thrilling story of the progress of 10 yr. of the struggle against obstacle and opposition, of the provision now made for the great trade which is to come with the opening of the Panama Canal, and the outlook which the city has ahead as the trade with the far east and with South American countries developes. His dream is of a harbor, the most convenient and most economical in the world for handling of merchandise—and he has a faculty of making his dreams come true.

ATTENDANTS AT THE AMERICAN BOILER MANUFACTURERS' ASSOCIATION CONVENTION

The address was greeted with the hearty applause that it deserved and President Meier in replying stated his belief in New Orleans as a coming World City, a great metropolitan port and the point of greatest vantage for the commerce of the great central section of the country.

In speaking regarding a telegram from Richard Hammond of Buffalo, as to the adoption of standard specifications for boiler material, construction and operation Col. Meier spoke of the proposed limits of sulphur at 0.03 and phosphorus at 0.04 asked by the boiler manufacturers and the limit desired by steel makers of over 0.03 on sulphur because of the difficulty of keeping within the lower limit when making steel of high tensile strength by the basic open-hearth process. The high sulphur tends to make steel red short and difficult to work in flanging and bending.

Against Free Sugar

SHORTLY after the opening of the afternoon session the matter of the removal of duty from sugar was taken up as affecting vitally an industry of Louisiana and the western beet sugar states—an industry which is a large user of boilers and steam machinery. Several members spoke against the passage of the bill and Mr. Porch, being called on stated that there was some $200,000,000 invested in the industry in Louisiana and $300,000,000 in the rest of the country; that 800,000 hp. of boilers were in use in the state and 1,200,000 hp. throughout the country in the manufacture of sugar; and that removal of duty meant practical destruction of this industry and rendering the plants worthless.

W. P. Luck then presented a resolution strongly condemning the bill and its passage without adequate hearing being granted to the interests involved, and appealing to congressmen and senators to kill the bill. This resolution was passed and Mr. Porch was delegated to wire the substance of the action to the representatives at Washington.

Rivets and Riveting

IN his paper on Rivets, D. J. Champion spoke of the distrust of steel as rivet material 20 yr. ago, and the improvement in quality of material since until now the mild steel rivet, which is after all more than 99 per cent pure iron is better than wrought-iron for most purposes.

He protested against some rivet tests as being adapted for iron but not fair to steel, especially the nicking and bending test, which iron will stand because of its fibrous nature, but steel cannot be expected to because it is crystalline in structure. Also against the hammering of rivets not only after they are blue, but until they are "black and blue," a practice which tends to increase crystallization and the starting of flaws between head and body.

Under the heading "Experiences" Mr. Champion stated that he would: 1. Hold some reliable maker responsible for quality and workmanship of rivets. 2. If holes are not reamed, be sure that faces of the holes are parallel and without undue overlap. 3. Be sure that rivets are heated carefully; hand-driven to almost white heat, for pneumatic riveter to bright cherry red; for hydraulic riveter to dull cherry red; heat being regulated according to the pressure to be used and pressure relaxed when the rivet is nearly cold. 4. Never continue hammering after the rivet is blue. 5. Allow only 1/32 in. for diameter of hole over diameter of rivet, especially for high-pressure work, as trying to fill a big hole by overexpanding of the rivet by compression weakens the steel. 6. Do not use heavy pneumatic tools on small rivets, but have size of tool proportioned to size of rivet. 7. Never drive cold made rivets cold without annealing. 8. Do not use high-pressure blast on rivet without a wall to break the flame, and even then use a graduating valve so that the pressure can be reduced to not over 15 lb. per sq. in. 9. Do not allow the rivet to soak too long or to form scale. When stopping at noon or night, remove from the furnace and reheat or use new rivets. 10. Never use a rivet which shows signs of starting to melt, as it may drive loose in the hole, causing a leak or the head come loose when calking.

In closing, Mr. Champion spoke of the need of pressing on, not resting on present achievement, as the improvement in steel is not yet at an end, and alloy-steels are showing surprising results which may lead us far beyond anything of which we now dream.

Riveting Data

FOLLOWING this address H. J. Hartley of Philadelphia, took up the question raised at the meeting of last year as to the proper pressure to be used in driving different sized rivets. He stated that the riveting is most important, as bad work in this respect impairs the vitality of an otherwise good job and shortens its life; while a good riveting will often overcome other defects. Again, defects in a job of riveting are often difficult to find in a first inspection but will appear and give great trouble after the boiler has been for a time in service. In practice it has been found that because of the holding power of the heads on the plates by clamping and friction, the net area of the rivets should exceed the net area of the plates to give the strongest possible joint.

In driving a rivet hot the tendency is for the end where the head is being formed to upset first and fill the hole, and friction of rivet metal against the sides of the hole tends to prevent the free flow of metal to fill the space next the head already made. This is a cause of loose rivets and the necessity of calking rivets.

To avoid this effect Mr. Hartley uses a fillet under the head of the rivet and countersinking the hole on both sides of the joint. This gives a wedging action which jams the fillet in to fill the hole, makes a joint without calking and clamps the plates together firmly. In his practice, which is hydraulic riveting, he makes allowance as follows:

For ¾-in. rivet, allow hole-rivet diameter +1/32 in.
For ⅞-in. rivet, allow hole-rivet diameter +3/64 in.
For 1 -in rivet, allow hole-rivet diameter +3/64 in.
For 1⅛-in. rivet, allow hole-rivet diameter +3/64 in.
For 1¼-in. rivet, allow hole-rivet diameter +1/16 in.
For 1⅜-in. rivet, allow hole-rivet diameter +1/16 in.
For 1½-in. rivet, allow hole-rivet diameter +1/16 in.

This is for holes drilled through both plates from the solid metal, plates being clamped together. Rivets are heated to a medium cherry red at the head and dark cherry red at the point.

As to driving pressure to be used, tests by Wm. Sellers & Co., on ⅜-in. rivets showed that with 10,000 lb. the rivet swelled and filled the hole; with 20,000 lb. the head was well formed; with 30,000 lb. the rivet was well upset and headed; with 40,000 lb. the plates began to stretch, and this increased as the pressure was increased up to 60,000 lb. From this it was deduced that the best pressure for cold rivets was 150 tons or 300,000 lb. per sq. in. of section.

Tests by Vauclain were made on 6 sets of 9/16-in. plates, 6 plates to a set, drilled for rivets increasing

in diameter from 5/8 in. by 1/8 in. to 1¼ in. Pressures used were for 5/8-in. rivets, 25 tons; for ¾-in., 33 tons; for 7/8-in., 50 tons; for 1-in., 66 tons; for 1⅛-in., 75 tons; for 1¼-in., 100 tons. The joints were cut in halves longitudinally, and showed that for all except the 1¼-in. the metal under and around the rivets was indented.

For a second test the holes were punched, and with the same pressures showed no indentation while the holes were well filled. The conclusion reached was that the best pressures were:

For 5/8-in. rivets, 25 tons=163,00 lb. per sq. in.
For ¾-in. rivets, 33 tons=149,00 lb. per sq. in.
For 7/8-in. rivets, 50 tons=166,200 lb. per sq. in.
For 1 -in. rivets, 66 tons=168,000 lb. per sq. in.
For 1⅛-in. rivets, 75 tons=151,200 lb. per sq. in.
For 1¼-in. rivets, 100 tons=163,000 lb. per sq. in.
Average, 160,000 lb. per sq. in.

From which pressures for other sizes can be figured. Experience of 20 yr. on plates from 3/8 to 1¾-in. thick and rivets 5/8 to 1½-in. diam. has proved this practice to be satisfactory.

An advantage of hydraulic riveting is the heavy

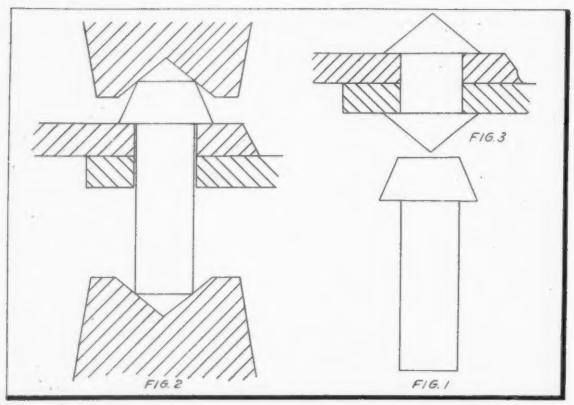


FIG. 1. ORDINARY COMMERCIAL RIVET. FIG. 2. ACTION OF CONE DIES ON RIVET. FIG. 3. CONE HEADS AS COMPLETED

closing effort which may be exerted at the end of the stroke of the ram, by a surge effect. This amounts with 1200 lb. pressure in the accumulator to increasing the pressure to 2000 lb. for an instant, after which the ram rebounds and returns. This effect is secured by opening the riveter valve at first slowly, giving a wire-drawing effect and slow ram movement until the rivet is upset into the hole, at the end of the stroke, opening the valve rapidly giving a blow effect

Shape of Rivets

WITH the ordinary commercial rivet having pan head and square end to be driven by cone dies as shown in Fig. 1, the metal must flow up into the dies to get bearing on the conical surface before any pressure is available to upset the rivet or form a head. With the round head and round dies, less flow of metal is necessary and upsetting to fill the hole takes place before the head is formed because the pressure comes more nearly central along the axis of the rivet. Rounding the end of the rivet to the radius of the die would be still better, but is not necessary; nor is it necessary to make the head a hemisphere. The thickness of head should be such that the shearing strength to strip the head from the rivet body will equal the tensile strength of the body. Figure 6 shows the relative values of the 2 shapes with the same amount of material in the heads. The round head is some 33 per cent the stronger; it also calks better, if necessary, for the thin edge of the cone head curls away from the plate under the action of the calking tool, while at the first stroke of the tool, the metal of the round head forms an arch above the tool forcing it and the metal of the thick edge down against the plate.

Tube Making

AT the Wednesday morning session papers were first taken up describing the manufacture of tubing, one on wrought-iron tubes by Geo. Thomas 3rd, of the Parkesburg Iron Works, one on seamless drawn steel tubing by J. J. Dunn of the Shelby Steel Tube Co. These gave in detail with lantern slides the processes used and shop scenes in the factories, as well as discussing the changes in metal due to the different processes.

Reports of Committees resulted in the choice of Cleveland, O., as the meeting place for 1913 and reelection of the entire board of offiers for both Boilermakers and Supplymen's Associations as follows:

New Officers

AMERICAN Boiler Manufacturers Association; President, E. D. Meier, New York, N. Y.; secretary, J. D. Farasey, Cleveland, O.; treasurer, Jos. F. Wangler, St. Louis, Mo.; first vice-president, T. M. Rees, Pittsburgh, Pa.; second vice-president, J. Don Smith, Charleston, S. C.; third vice-president, W. A. Brunner, Phillipsburg, N. J.; fourth vice-president, H. C. MacKinnon, Bay City, Mich.; fifth vice-president, M. H. Broderick, Muncie, Ind.

Supplymen's Association; president, J. T. Corbett, Chicago, Ill.; vice-president, Thomas Aldcorn, New York, N. Y.; treasurer, H. B. Hare, Cleveland, O.; secretary, F. B. Slocum, Brooklyn, N. Y.

Steel Composition

CHARLES L. Huston of the Lukens Iron and Steel Co., presented a mass of data and interesting facts as to the segregation of steel, showing that although the average composition as shown by test from the ladle may be as desired, variation in the composition will occur. This is due to the action of the gases which are given off between the chilled portion of the metal and the molten part. At first these rise to the surface and escape causing a circulation in the mould up around the edges and down in the center. This seems to carry the carbon and other hardening elements to the top of the mold, raising the carbon content and the strength at that point.

As the metal cools, it becomes too thick for the gas bubbles to force their way up, and they are caught in the metal, forming a layer of slightly porous metal, the height of the ingot; watching the slag and the temperature of pouring it is sought to retard the cooling and keep the gas ring as far toward the center of the ingot as possible; it usually comes at 2½ to 3 in. from the surface.

During the processes of reheating and rolling, these pores are worked out, but the uneven distribution of carbon through the billet is not eliminated, so that test pieces from the part of the plate formed from the middle of the top end of the ingot show decidedly different composition and test from those taken near the outside of the bottom. The effect is more pro-

nounced in small, thin billets than in large ones. Carbon, silicon and manganese are the elements mostly affected by segregation, and are the ones that have most effect on the strength of steel. Sulphur and phosphorous make a difference in the readiness of hot working in flanging and bending, but Mr. Huston stated that they do not greatly affect the breaking strength cold.

One set of tests on a plate 335 by 94 by 29/32 in. rolled from an ingot 48 by 20 in. and weighing 11,000 lb. varied from carbon 0.5 and a breaking stress of 78,100 lb. at the top center to carbon 0.2 and stress 59,500 lb. at one corner of the bottom; the ladle test specimen showed carbon 0.26.

In another plate rolled to ¼-in. gage from a billet 26 by 12 in. weighing 2800 lb. showed at the center plane of the ingot for the middle top, carbon 0.3, manganese 0.46 sulphur 0.037, phosphorous, 0.022, breaking stress 62,740 lb.; for the corner bottom, carbon 0.16, manganese 0.42, sulphur 0.02, phosphorous, 0.024, breaking stress 55,900 lb. The ladle test showed carbon 0.19.

Numerous other tests were given, also microphotographs showing the construction of the metal at different parts of the ingot.

Boiler Explosions

CARRYING into the afternoon session, S. F. Jeter of the Hartford Boiler Inspection and Insurance Co., read a paper on Boiler Exploisions, Their Causes and Prevention.

Mr. Jeter attributed explosions to the boiler at some point being too weak to carry the strain put upon it, either because of faulty design or the strain from years of use. He advocated the manufacturer stamping the boiler with his name and the pressure that it is designed to carry; this will not insure aganist overstrain after years of use, but will be a precautionary measure.

Grooving or cracking, which is an occasional source of weakness comes from local bending back and forth, particularly where a stiff piece is joined to one more elastic. The remedy is to use shapes that do not tend to change with internal pressure, and so to design that the movement will be distributed over a large area instead of being localized.

It is not certain that reinforcing as now used is of the best form or size, as much of it is designed by rule of thumb. All parts should be carefully inspected and tested for material and workmanship, as the makers reputation is at stake.

Imperfect circulation is a cause of trouble as it deposits scale at bad points and allows pockets of oxygen liberated from the water by heat to form and cause severe local corrosion; good circulation will carry the liberated gas to the surface where it will be carried away with the steam.

Some other causes of trouble have been, in the past bad workmanship, lack of proper flare in the tubes and nipples of water-tube boilers, covering up of mistakes by workmen in the shop, negligence in care and operation, delay in making repairs as soon as needed.

No cast iron should be used where subject to pressure strains. Boilers should not be forced beyond a reasonable duty for the heating surface provided, as the tendency now is to work a boiler at very high capacity, and under such conditions, overheating or overstraining may easily take place. Lack of care may result in a stopped feed pipe or water column connection with consequent burning; oil in the boiler, or tampering with the safety valve are sources of danger.

A badly welded tube cannot be inspected after it is in place, hence all tubes should be thoroughly looked over before placing. Seamless drawn tubes were advocated to be made by the hot process or else annealed before using.

Experience has shown that a "heavy" tube is safer than the common thickness even though the latter seems to have an unnecessarily high factor of safety. In fast forcing, the steam bubbles form rapidly on the tube surface and may leave the tube dry in spots, so that it gets a high temperature; this frequent alternation of heat and the comparative cold when the bubbles pass on and water strikes the surface again affect the metal strength and the thick tube is better on that account.

Lap seams fail because of bad design or abuse of the boiler, not, Mr. Jeter thinks, because of inherent weakness of that type of joint.

Stringent laws, competent periodic inspection and proper inquiry by the government into all explosions, to fix the cause and responsibility with no white-

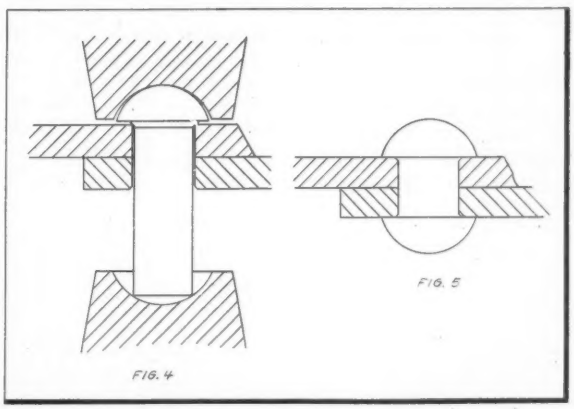


FIG. 4. ROUND HEAD RIVET ACTION IN CUP DIES. FIG. 5. COMPLETED ROUND HEAD RIVET WITH FILLETS

washing of those to blame will reduce the carelessness in operation which is one great cause of disaster.

Mr. J. T. Corbett, quoting from The Locomotive, showed one case of novel boiler staying where as he said the effort was made to cure boiler "appendicitis without an operation." A bag formed near the back end, and a rod was put in as indicated, the offset being used presumably to permit of "expansion and contraction."

Following this paper H. C. Meinholtz, of the Heine Safety Boiler Co., read a paper on How Modern Boiler Shops Should Be Equipped, in which he gave interesting facts as to the points to be especially considered and described in particular the arrangement of the shops of The Heine Company as given in the issue of Practical Engineer for Feb. 1910, p. 129. Mr. Meinholtz dwelt especially on the proper arrangement of machinery to avoid rehandling of materials, provision of ample space for the workmen, the arrangement of the windows for giving plenty of light and ventilation; this last mentioned feature was accomplished by the use of a 3-sash window, the top and bottom sash being connected by cords running over simple pulleys and balancing each other, while the middle sash is stationary. In this way 2/3 of the window space is available

for ventilation in summer and the use of a box frame and sash weights is avoided. The arrangement is a good one for engine rooms as well as for shops.

In discussion of the paper, Mr. Meinholtz mentioned the fact that a leak in the ram of the inverted accumulator which was used for the hydraulic riveting machines was finally stopped by putting in a mixture of neat Portland cement and gradually putting on the pressure, forcing this cement into into the opening. Corrosion of a cylinder by anti-freezing mixture was mentioned by one of the members as a difficulty encountered with a hydraulic accumulator ram, but in his case the remedy had to be the installation of a new ram.

This paper was followed by a very complete treatment of the subject of Compressed Air and its Uses, by Thomas Aldcorn, of the Chicago Pneumatic Tool Co. Mr. Aldcorn's complete paper was not available at the time of the reading, and has not reached us in time for use in this issue, but will be given at considerable length later.

Suggestions for Improvement

W. H. S. BATEMAN, an associate member from Philadelphia, spoke on the subject of the Boiler Manufacturers' Association as it is and as it ought to be, and praised particularly the attitude of men like Mr. Huston in giving to the world information which has been acquired by years of experience and study in order to help the general good of boiler making. Mr. Bateman also spoke of the difficulty of getting boiler

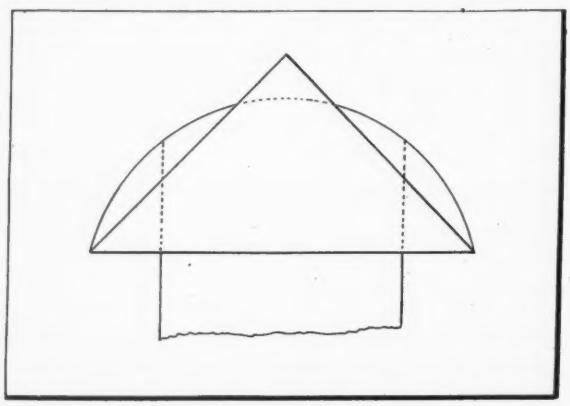


FIG. 6. COMPARISON OF ROUND AND CONE HEADS HAVING EQUAL AMOUNTS OF METAL

manufacturers in some sections to co-operate because of bitterness aroused by keen competition. He gave instances of such bitterness and urged that the general good should be considered. He told of the good work that has been secured in the marine field by the marine builders getting together, and of the difficulty of making the business managers of big concerns manufacturing stationary boilers realize the advantage of having representatives at the convention.

He advised that there should be sections of the associations to take up different branches, first marine boilers, second, water-tube boilers, third, return tubular boilers, fourth, house heating and low-pressure boilers, fifth, locomotive boilers; that there should be sectional meetings; and that a paid secretary to give a large part of his time to the association should be employed to represent the association at meetings in different parts of the country and to meet with boards of boiler rules.

He urged that boiler rules be not approved without careful investigation of the conditions in each state and also the adoption of the uniform rules in every state in the country.

In his remarks and in further discussion which followed the point was clearly brought out that it will be impossible to get a code of national rules by action of Congress, since such action would not be constitutional, but there is nothing to prevent the adoption of a uniform code of rules by the different states and this method is the one which is to be worked out, if possible. Help can be had from the Commission on Uniform Laws which is an official body with members appointed either by the legislature or the governor of each state and which takes up each year in convention the subjects on which it is desirable to have uniform legislation and the best form of such legislation. This is a commission of lawyers and is able, therefore, to tell what laws and forms are admissible in different states and thus avoid legal complications in the framing of laws which it is sought to have made uniform.

Mr. Bateman spoke in glowing terms of the work which has been done by the present secretary of the Supply Men's Association, F. B. Slocum, in furthering the interests of the Manufacturers' Association and in getting so large an attendance at the meeting and finally moved a vote of thanks which was unanimously carried. At the suggestion of Col. Meier a vote of thanks was also extended to Mr. Bateman for his discussion of the affairs of the association and his suggestons.

Conditions in regard to railroad matters were discussed briefly and resolutions were offered by Chas. F. Koopman, Jr., of Boston, urging upon the Interstate Commerce Commission the importance of permitting the adjustment of freight rates that would not curtail the revenue of railroads so that their borrowing power might be increased and the investment in railroad securities made attractive with the object of permitting development of railroad facilities necessary to give adequate service for the carrying of passengers and freight. Mr. Koopman pointed out that traffic has increased rapidly and railroad facilities slowly since 1907, and a further enlargement of tonnage to be hauled will result in shortage of cars and a serious handicap to shippers and that lack of funds is now endangering the development of railroad facilities.

Adjournment was then taken and the committee on boiler specifications went into session and completed its work, the report being presented on Thursday morning.

The first paper on Thursday morning was by H. J. Hartley, of Philadelphia, on Generalities of Boiler Making Plants, in which he gave some general principles resulting from his 40 years' experience. He first thanked the association for the honorary membership conferred upon him last year, then gave as the requirements of success the manufacture of a high quality and high quantity of product at low cost, this requiring a proper personnel or organization, proper training of that organization, proper equipment of the requiring a proper personnel or organization; proper tem, good discipline, experienced foremen with good business sense, who will watch time sheets and costs,

and the utilization of the piece work system were some of the features advocated.

Resolutions on the death of Hugh Tudor, who died on Nov. 19, 1911, were offered, Mr. Tudor being one of the charter members and a regular attendant at the meetings. A letter of regret from Geo. Uhler, supervisor and inspector general of marine boilers, was read, also a letter from A. J. Baumhart in regard to the newly revised Ohio boiler rules. The Hartford Boiler Inspection & Insurance Co. were accepted as associate members, as were also the Burke Furnace Co., of Chicago, and the Marion Steam Shovel Co., of Marion, Ohio.

W. O. Hart, of New Orleans, spoke on the subject of Uniform State Laws and in regard to the Commission which has already been mentioned. He told of the work already accomplished by this commission, and invited the association to send a representative in regard to uniform boiler inspection laws to the meeting which will be held next summer. This invitation was accepted and L. C. Conley, of Cleveland, was recommended as one of the representatives at the convention.

Boiler Specifications

THE report of the committee on uniform boiler specifications was then taken up and read by Col. Meier, chairman of the committee. This report was based largely on the rules of the Massachusetts Boiler Board, gave the history of the A. B. M. A. specifications and showed what changes have been made and what success has been had. The report is long and involves a discussion of both the Massachusetts boiler rules and the old Boiler Manufacturers' Association specifications, and will, therefore, be given in a later issue, when more time can be devoted to a full discussion of the features.

At the conclusion of the reading of the specifications it was voted that the report be accepted and the recommendations adopted, and in speaking to this question, L. C. Conley, of Cleveland, emphasized the need of actually doing something in regard to getting laws passed and putting these specifications into effect. He spoke of the regulations for government of marine engines and locomotives and the lack of uniformity in specifications for stationary work and gave instances of difficulties which had been encountered by boiler makers when making a boiler for one location that was afterwards sent to another and refused because of alleged lack of conforming to local specifications.

Resolutions were then presented by Secretary J. D. Farasey, thanking the authors of the different papers for their interest, Mayor Behrman and Mr. Porch for courtesies and the gentlemen and ladies of New Orleans who had given so much time and thought to the making of the stay of the association in the Crescent city a pleasure.

In the final action on the specifications the thought was that special effort should be made to get the Massachusetts rules revised to accord with the recommendation of the A. B. M. A. committee, to have the Ohio rules now on the point of passage arranged to conform with these uniform specifications and to secure, if possible, changes in the rules of such cities as Chicago and Detroit, where local ordinances are in force. The committee was continued and instructed to take up criticisms which might be sent to it, to make revision of the specifications in accordance with these suggestions and their own judgment after the end of 3 months and then to take active steps to secure legislation. The committee reporting consisted of E. D. Meier, chairman, Thomas M. Rees, Barth Scannell, Henry J. Hartley, Chas. F. Koopman, Jr., A. J. Schaaf, H. C. Meinholtz and Wm. A. Brunner.

No display of the goods of the associate members was made, but representatives of many of the companies were present and assisted in insuring the comfort of the members of the A. B. M. A. in attendance. The total registration at the convention was 139, including among others the following:

Thomas Aldcorn, Chicago Pneumatic Tool Co., New York, N. Y.; J. S. Barelli, Heine Safety Boiler Co., New Orleans; W. H. S. Bateman, Parkesburg Iron Co., Philadelphia, Pa.; R. T. Burwell, Chief Inspector, Hartford Steam Boiler Ins. & Insp. Co., New Orleans; John C. Brill, Portsmouth Steel Co., New Orleans; D. J. Champion, Champion Rivet Co., Cleveland, O.; John Corbett, Jos. T. Ryerson & Son, Chicago, Ill.; John A. Cotter, Sup'g Inspector Steam Vessels, 10th Dist., New Orleans, La.; J. F. Duntley, Chicago Pneumatic Tool Co., Detroit, Mich.; S. H.

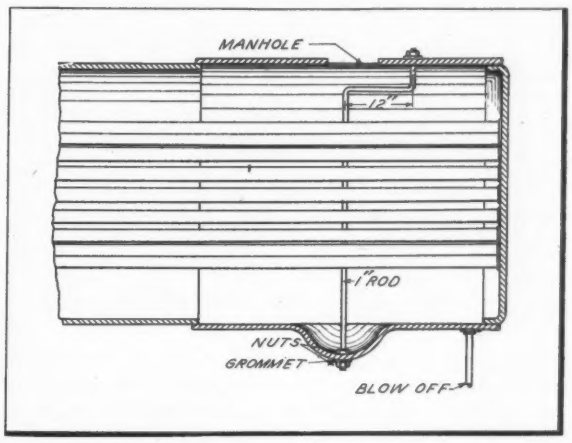


FIG. 7. PECULIAR THROUGH BRACING FOR A BAGGED BOILER

Daniels, Walsh & Weidner Boiler Co., Chattanooga, Tenn.; J. D. Farasey, Prop'r Teachout Boiler Works, Cleveland, O.; J. J. Finnigan, J. J. Finnigan & Co., Atlanta, Ga.; H. B. Hare, Asst. Secy. Otis Steel Co., Cleveland, O.; H. J. Hartley, Cramp Ship Building Co., Philadelphia, Pa.; James Kelly, James Kelly Iron Works, New Orleans, La.; William P. Luck, Erie City Iron Works, Erie, Pa., New Orleans, La.; F. W. Milbourn, Sales Mgr. Southern Engine & Boiler Works, Jackson, Tenn.; Col. E. D. Meier, Prest. Heine Safety Boiler Co., New York, N. Y.; J. H. Nicholson, 1st Vice Prest. National Tube Co., Pittsburgh, Pa.; James W. Porch, Rep'g Lukens Iron & Steel Co., New Orleans, La.; T. F. Rowland, Jr., Prest. Continental Iron Works, New York; George N. Riley, National Tube Co., Pittsburgh, Pa.; George Rees, Vice Prest. Chicago Pneumatic Tool Co., Chicago, Ill.; Arthur L. Rice, Managing Editor, Practical Engineer, Chicago, Ill.; S. F. Jeter, Sup'g Inspector Hartford Steam Blr. I. & I. Co., Hartford, Conn.; Fred L. Joubert, Payne & Joubert, New Orleans, La.; J. J. Kelley, National Tube Co., Pittsburgh, Pa.; C. B. King, Chf. Engr. Marion Steam Shovel Co., Marion, O.; Fred R. Low, Editor Power, New York, N. Y.; George Mason, Scully Steel & Iron Co., Chicago, Ill.; John A. Murphy, New Orleans, La.; E. F. McCabe, McCabe Boiler Works,

(Continued on page 392.)

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IS CHEAP FUEL EXPENSIVE?

We are led to this wonderment by wandering through several plants where every facility had been provided for convenience in handling cheap fuel. In one of them, no hand labor was required to get fuel into or ashes out of the plant; everything was automatic and firing was a "snap." The others were nearly as good, and these arrangements made it possible to use a low cost fuel, and left plenty of time to look after the rest of the plant.

But the way steam was blowing was a caution. There was a steady fizz from leaks at joints and around valve stems; pumps, compressors, water columns, steam lines, stop valves, even a cylinder head joint were helping out the blast. And that loose cylinder joint was at the crank and so that the whole frame moved and the main bearing foundation rocked at each stroke.

Fuel was cheap, nobody had to shovel, nobody took much interest in wasted steam; perhaps a "sassy" jet of hot water might have received more attention, but steam is not so discomforting, and doesn't make a muss.

If fuel had been costly, wouldn't somebody—owner, superintendent or chief—have been more anxious over those leaks? If lost steam meant extra shoveling, wouldn't fireman or ash wheeler have been interested to cut down the coal and ashes handled? And, if somebody had shown some interest, wouldn't there have been saving enough in the wear and tear on that plant to pay considerable extra fuel cost?

Of course, the leaks ought to have been stopped anyway; but "folks is human," and it's easy to let things go unless there is a motive strong enough to make them move. Maybe high cost of fuel results in saving other things besides the coal pile.

NEWARK, N. J., is to hold a great industrial exposition under the auspices of the Board of Trade, May 13 to 25, to accelerate the industrial, commercial and educational interests of the city. Displays will be made in the First Regiment Armory and grounds, the building being one of the largest and best adapted to exhibition purposes in the United States.

It is claimed that 100,000 different articles are manufactured in the 3000 shops of the Newark industrial district, the diversity being proportionately greater than that of any other manufacturing district in the country. Not only will the products of Newark's factories be shown, but also the processes of manufacture.

For many years the city has been widely known as the nation's leader in the manufacture of gold jewelry, while its high rank has long been recognized in the shoe and leather industry, the manufacture of high-class machinery, chemicals, paints and varnishes, linoleum, celluloid, metal specialties, and advertising novelties. It is the purpose of the Exposition to teach the world the variety, extent and quality of all the products made within the city's boundaries.

NEWS NOTES

THE WHEELER CONDENSER & Engineering Co., of Cartaret, N. J., manufacturers of surface and jet condensers, pumps, cooling towers, etc., announce that their Cincinnati Office has moved from 111 Ingalls Building, to offices in the Mercantile Library Building of the same City. The new office will be in charge of Richard L. Strobridge, who was formerly connected with the Boston office of the Wheeler Condenser & Engineering Co.

SOUTH PARK AND EAST SIDE RAILWAY COMPANY and the San Diego Wood Products Company have sold their electric railway to the San Diego Electric Railway Company.

THE SEATTLE ENGINEERING SCHOOL (Incorporated) formerly Seattle Steam Engineering School, 308-9 Oriental Building will occupy its new building on Third Avenue and Pine Street about April 1st. Steam, electrical and gas engineering, both theoretical and practaical, will be taught.

THE OMAHA ELECTRIC LIGHT & Power Co. is to be taken over by a syndicate controlled by H. L. Doherty, of New York.

C. C. OWENS HAS recently been placed in charge of the Detroit District Sales Office of the Westinghouse Electric & Mfg. Co., with the title of District Manager. Mr. Owens was born in 1877 near Annapolis, Md., and graduated from Columbia University, Washington, D. C., with the degree of Bachelor of Science in electrical engineering. He entered the employ of the Westinghouse Electric and Manufacturing Company in 1896, taking apprenticeship course for 3 yr., after which he spent 4 yr. in the engineering department specializing on switchboards and controllers. For the last 8 yr. he has been connected with the New York Sales office, having had charge of the industrial and power division for the 2 yr. previous to his transfer to Detroit.

THE SEVENTEENTH ANNUAL CONVENTION of the New York State Association, N. A. S. E., will be held in the City of Yonkers, on June 14th, 15th and 16th, 1912, every effort is being made by Chairman Graham and the Committee on Arrangements to make this the largest and most cosmopolitan convention of engineers ever held in this state. In order to add interest and show development of engineering methods and appliances, the committee has arranged to have in conjunction with the convention, an exposition, where manufacturers and dealers may exhibit all kinds of engineering appliances as well as everything needed in a first class manufacturing plant. The sessions of the convention will be held in the armory, so that everyone attending will have an opportunity of inspecting the exhibits. Intending exhibitors should notify the committee immediately of the amount of space wanted. Headquarters in the Getty House—five minutes' walk from the armory. William Roberts, Tuckahoe Road, Yonkers, N. Y., is the secretary.

EDUCATIONAL BUREAU OF THE Illinois Central Railroad Co. and The Yazoo & Mississippi Valley Railroad Co. has already afforded a means whereby employes might better inform themselves about railroading; and is now taking active steps by means of explanatory lessons, to assist in the prevention of accidents, and lated by means of moving pictures to illustrate the right and wrong ways of doing things.

Going one step further, the Educational Bureau is now in position to assist employes in legal matters, to a certain extent. It will endeavor to issue from time to time pamphlets for general distribution, or to publish articles in the Employes Magazine, dealing with matters wherein experience has proven that for want of legal aid employes have been imposed upon so that they have suffered either financial loss or worry and unpleasantness which could have been avoided had they known their legal rights.

The first step that the Bureau will take will be to explain the methods of loan sharks—to tell employes who have suffered from the wiles of these sharks what their rights are, and to offer employes who are at present in trouble as a result of having patronized these loan sharks or companies, aid in straightening out their affairs and getting clear of the clutches of those engaged in the illegal practices by means of which the loan sharks exist.

ASHLEY & KAUFMAN, CONSULTING ENGINEERS, announce that they have opened engineering offices at 417 5th Ave., New York., specializing in the design of heating, lighting, ventilating, refrigerating and sanitary installations.

THE NATIONAL OIL MILL SUPTS. ASSOCIATION will hold its Annual Convention on June 12-14, at Memphis, and expects to have the largest gathering of practical cotton seed oil mill men that have ever been gotten together at any one time in the history of the cotton oil mill industry. There will be a large exhibit of cotton oil machinery and engineering supplies pertaining to the trade, and anyone interested in securing exhibit space can get all their information from F. M. Smith, care Oriental Oil Co., Dallas, Texas. The Oil Mill Machinery Manufacturers and Supply Men's Association will meet at the same time in conjunction with the oil mill men. There will be low rates on all the railroads, and special rates at all the hotels in Memphis. Any one wanting information can obtain it by writing the secretary, H. E. Wilson, Pine Bluff, Ark.

AT AN EXPENDITURE of $1,000,000 the Savannah (N. Y.) Electric Company will erect a new power plant with a capacity of 11,000 kw.

PLANS ARE NOW well formed to erect a power plant at Bushnell, Ill., that will cost in the neighborhood of $100,000. It is the intention of the company to build a plant powerful enough to furnish electricity for at least eight other cities in McDonough county in addition to Bushnell.

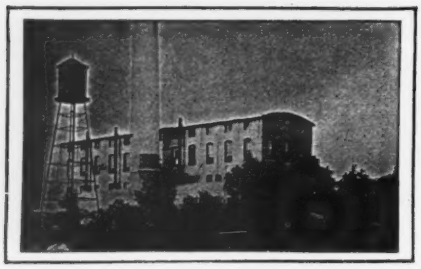
RAPID PROGRESS IS BEING made on the ice plant under construction for the Iron Mountain railway in its Argenta yards. The first carload of machinery for the plant has already arrived.

Total cost of the plant, when complete, will be about $50,000, and it will have a capacity of about 125 tons of ice per day. The plant will be used principally for icing the cars used in the fruit and truck business.

WORK HAS PROGRESSED so far on the Nisqually (Wash.) municipal power plant project that the power house at La Grande is ready to receive the machinery and equipment to be shipped from Milwaukee. The machinery which is ready consists of only the first two 8,000 horsepower units, however.

WITH GREAT SORROW we learn, as forms are going to press, of the death of Mr. Louis L. Rice, formerly publisher of Practical Engineer and recently general manager of National Engineer. We regret that time does not permit of a more extended notice in this issue.

SOME MEN loose their jobs through bad management, others through bad luck.



Power Apparatus

In Shop and Market

New Ideas in Making, Buying and Selling

A NEW MACHINERY BUILDING

MACHINERY interests have been divided in Chicago as to location, offices being maintained in the loop and show rooms, when at all, placed west of the river for space and expense reasons. The buildings used for show rooms were not of a character nor was there suitable location for offices in that vicinity.

Realizing this lack, G. A. Buhl & Co. have planned the erection of a building suitable for machinery and engineering display and office room, to be devoted solely to such purposes at the southeast corner of Madison and Clinton Sts., directly opposite the new Chicago and Northwestern Station, and to be known as the Madison-Terminal Building. On the ground floor will be a fine cafe and an L shaped space devoted to a first class restaurant and lunch room. The other 7

FIG. 1. MADISON-TERMINAL BUILDING, A NEW MACHINERY CENTER

stories will be divided into spaces of 1500 sq. ft. or less, as may be desired, arranged around a court so that all have good light and air. The building will be of fireproof construction, modern in all details, 80 by 140 ft., and of moderate rental. It is expected to be ready for occupation by Nov. 1, 1912.

THE AMERICAN STEAM GAUGE & VALVE MANUFACTURING CO. has so improved and increased its facilities that it now has a capacity of 1000 complete steam gauges per working day, and General Manager Phillips expresses the hope that this will enable his company to keep up with the demand for a few months, at least.

LUNKENHEIMER CAST STEEL VALVES

SUPERHEAT and high steam pressures have created a demand for valves of greater strength and durability than those of cast iron. Anticipating the requirements of the trade, The Lunkenheimer Co., Cincinnati, O., has designed a complete line of globe, angle, cross, gate, check, non-return, boiler stop, etc., made of cast steel, all of which are in actual use, in a large number of high-pressure power plants.

With the exception of the largest sizes, the Lunkenheimer cast steel valves are made of crucible steel, melted in closed crucibles, out of all exposure to furnace gases, so that solid castings free from blow-holes are insured.

All these Lunkenheimer cast steel valves are annealed, which relieves all internal stresses and gives the fine crystalline structure, which is essential to strong steel.

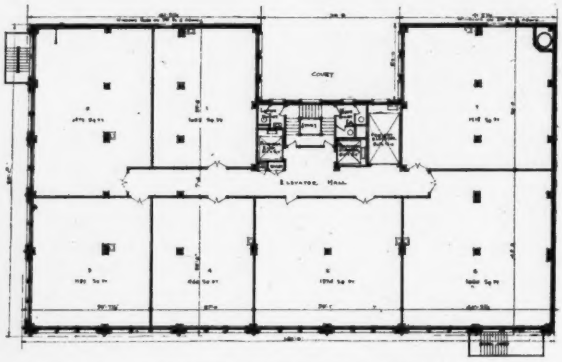


FIG. 2. SUGGESTED DIVISION OF A TYPICAL FLOOR

The tensile strength of this steel is about 80,000 lb. per sq. in., with a safe elastic limit and excellent elongation.

For various pressures and degrees of superheat and to meet the requirements of engineers who differ as to the material used, Lunkenheimer Cast Steel Valves are made in 2 combinations of material as regards the trimmings. For lower pressures and degrees of superheat, the company manufactures a large and complete line of cast iron and "puddled" semi-steel valves.

MURRAY SPECIALTY MANUFACTURING COMPANY

THE trade in general will be interested to learn that all holdings of the Murray Automatic Boiler Feed Co., of Detroit, have been taken over by a new company to be known as the Murray Specialty Manufacturing Co., which will continue the manufacture of the full line of Murray steam specialties.

The merits of Murray Automatic boiler feed regulators, pump governors, double-disc blowoff valves and other Murray devices are well known and do not require extended description here. We are showing, however,

a cut of the Murray boiler feed regulator, and will briefly describe its principles of operation. It automatically holds the water in the boiler at the center gage and thus furnishes dry steam to the engine, prevents the possibility of accidents from low water, and effects saving in fuel.

Whenever the water in boiler falls below its normal level, the float in column will open needle shaft valve and admit steam through the ¼-in. pipe into the lower end of the cylinder, thereby forcing up the piston against the tension of the spring and through the piston rod, opening the regulating valve. This will admit water through the feed pipe into the boiler until the normal level is restored. As soon as this occurs, the needle valve will again be closed by the rising of the float, shutting off the steam from the ¼-in. pipe and allowing the spring to compress the piston, closing the regulating feed, or valve.

It will be gratifying to both dealers in and users of steam specialties to know that the new company, while a separate and distinct organization, is under the same management as the Wright Manufacturing Co., and the Austin Saparator Co., and that the new company will therefore have for the manufacture and marketing of the Murray line of steam specialties, capable, energetic, and painstaking management.

SECTION OF MURRAY AUTOMATIC BOILER FEED REGULATOR

NONPAREIL STANDARD COVERING

THESE coverings for high-pressure steam pipes, boilers, etc., are made in sectional block and cement forms and are composed of a fossil earth combined with asbestos fibre. The earth is a peculiar white substance, light in weight, and often called fossil meal, consisting of microscopic skeletons of fish and plants which existed in the sea bottom ages ago. These minute bodies are practically pure silica, and under the microscope have the appearance shown in Fig. 1. There are a multitude of different forms, but all are hollow and contain air, and, as there are millions of them to the cubic inch, they form an excellent nonconductor of heat.

FIG. 1. FOSSIL EARTH UNDER THE MICROSCOPE

The Armstrong Cork Co., of Pittsburgh, which manufactures the Nonpareil coverings, has recently found a method of combining this ash into a plastic cement which is suitable for the manufacture of pipe covering.

Experiments by Wm. J. Baldwin and A. E. Morse, of New York City, checking together, have proved that a covering made of this earth has an exceptionally high efficiency in preventing heat radiation. It is also found that the Nonpareil covering will stand very high temperature without disintegration as may be proved by heating one side of the material with a blow-pipe to a white heat and plunging it immediately into cold water. A few hair line cracks will develop, but otherwise the surface will be found to be smooth and uninjured, and as hard as it was before the test.

Another advantage of the material is that it may be soaked in water for weeks, and after it is dried out it will be found in good condition and as strong as before.

Tests on the mechanical strength of the material showed that to crush a 4-in. lineal piece of 1½-in. covering requires 75 lb., which is a most satisfactory performance.

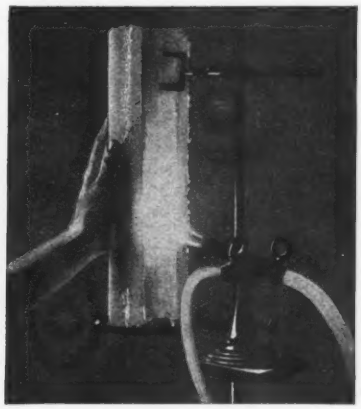


FIG. 2. BLOWPIPE TEST TO SHOW NONCONDUCTION OF HEAT

The standard covering is made in sectional form, covered with canvas, and is therefore easily applied and removed when necessary. It is also available in block and in plastic form for the covering of irregular surfaces, joints and flanges.

THE NEW YORK EDISON COMPANY has recently placed the order with The Terry Steam Turbine Company for 4 1000 g.p.m. boiler feed pumps to be installed at Waterside No. 1 Station. The centrifugal pumps are Jeanesville 8-in., 3-stage, solid bronze pumps and are direct-connected through flexible coupling to Terry single stage noncondensing turbines. This order makes the twelfth boiler feed unit of this capacity and make that has been purchased by the New York Edison Company within the last 5 yr.

GEO. W. LORD CO. has been awarded the U. S. Government 1912 contract for marine boiler compound, amounting to 125,000 lb. For almost half a century the Lord Co. has devoted practically its entire efforts to pushing the sale of its goods in the stationary field, but the organization has been enlarged recently. It has also entered the filter field with an apparatus that is automatic in its operation.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

(Continued from page 387.)

Newark, N. J.; Robert Munroe, Jr., Pittsburgh, Pa.; Emil W. Ritter, Burke Furnace Co., Chicago, Ill.; F. B. Slocum, Continental Iron Works, Brooklyn, N. Y.; J. Don Smith, Valk & Murdock Iron Works, Charleston, S. C.; B. Scannell, Scannell Boiler Works, Lowell, Mass.; A. J. Schaaf, Chf. Engr. Monongahela River Coal & Coke Co., Pittsburgh, Pa.; George Thomas, 3rd Treasr. Parkesburg Iron Co., Parkesburg, Pa.; Charles Tudor, Tudor Boiler Mfg. Co., Cincinnati, O.; John Thrash, Dallas Boiler Works, Dallas, Texas; M. G. Weidner, Walsh & Weidner Boiler Co., Chattanooga, Tenn.; C. L. Wilson, District Locomotive Boiler Inspector, with Interstate Commerce Com'n, Memphis, Tenn.; Hugo Weidmann, National Tube Co., New Orleans, La.; C. C. West, Manitowac Boiler Works, Manitowac, Wis.; Chas. J. Wangler, Wangler Boiler & Sheet Iron Works, St. Louis, Mo.; J. Jay Dunn, Elwood City, Pa., Genl. Supt. Shelby Steel Tube Co., Shelbyville, O.; C. L. Huston, Vice Prest. Lukens Iron & Steel Co., Coatesville, Pa.; I. B. Maitland, E. Keeler Co., Boiler Mfrs., Williamsport, Pa.; H. C. Meinholtz, Heine Safety Boiler Co., St. Louis, Mo.

Between Sessions

FEATURES of the entertainment were a reception and dance on Tuesday evening in the Hotel St. Charles music room, which lasted until a late hour, and at which excellent entertainment was provided by an orchestra and vocalists, a theater party at the Crescent Theater, with a dinner served afterwards in the Grunewald Cave, which was largely attended and greatly enjoyed by all, and a boat trip on the Mississippi River on the Steamer "Sidney" Thursday afternoon, which showed to the visitors the water front of New Orleans and the provision which has been made by the city for the handling of large freight shipments in and out. At the banquet on Thursday evening, which closed the session, the chief speaker was Jas. W. Porch, who emphasized strongly the lack of American shipping and gave some figures which were startling. He told of the entry of 1716 ships into New Orleans Harbor in 1911, not one of them on transatlantic service bearing the American flag. He called attention to the fact that we are building wharves, lighthouses and deep water harbors and the Panama Canal, all for the benefit of foreign ships and ship owners, that on the wharves of New Orleans there is plenty of cargo waiting, but no ships to be had; that when a party of Chicago business men wished to make a trip to Panama they could find no boat flying the American flag on which to make it, and were finally obliged to charter a German boat at an exorbitant sum for 2 weeks in order to make the trip; that a party from St. Louis encountered the same difficulty.

Mr. Porch called attention emphatically to the need of American ships; England has 12,065, Germany 4300, Japan some 1800, and the United States 9 seagoing vessels in the mercantile transoceanic service. The need of foreign markets for American made goods is becoming more and more apparent each year, but it is evident that without American ships to carry the goods to foreign markets there will always be a handicap because foreign owned and manned ships will give the preference to the carrying of goods from their own countries where possible. Our facilities for water transportation without ships to do the carrying are like a big railroad system without trains, and it is essential that we should keep in mind that it is not only the coast cities where the harbors are which need such transportation, but it is all the inland manufacturing cities and agricultural districts which have goods to be sent to other countries or even transported along our own sea-coast.

Looking to the opening of the Panama Canal a Japanese company is arranging for the establishing of a line of steamships from Japan through the canal to our Gulf ports and only a short time ago Japanese representatives were investigating the desirability of Galveston and New Orleans for the Gulf terminal. New Orleans capital is taking a step in this direction and will soon have a line of steamers in operation and it is vital that the country should keep this need clearly before it if the commerce of the country is not to be handicapped and greatly localized.

Other features of the evening were speeches by John H. Murphy, by J. A. Cotter, by W. P. Luck, and a presentation by Vice-President Thomas Aldcorn to John T. Corbett, president of the American Boiler Supply Men's Association, of a silver service in recognition of the work which President Corbett had done during the past year. After the speeches the hall was cleared and the younger members and ladies indulged in dancing until the early hours. Most of those in attendance at the convention remained over for a day or two of sight-seeing and found much of novelty and interest in the commercial development of the city as well as in the historical features.

CATALOG NOTES

FROM THE DETROIT LUBRICATOR CO., comes a special circular describing the Detroit Improved Standard Lubricator arranged with a bracket for supporting it. The bracket may be carried on the main steam pipe or any other firm support. It eliminates damage to the lubricator from vibration and jarring and is particularly useful on steam shovels, steam hammers, dredges and like outfits.

BULLETIN 7010 of the Reliance Electric and Engineering Co., Cleveland, O., describes automatic starting control for motor-driven machinery.

SMOOTH-ON IRON CEMENT No. 7 is for concrete work and is fully described in a new catalog issued by Smooth-On Mfg. Co., Jersey City, N. J. It is a hydraulic chemical iron cement, prepared in powder form and used alone or in combination with Portland cement or with Portland cement and sand. It makes concrete heavier, denser, harder and waterproof. One of the great values of this cement is that it will bond concrete to concrete, which makes it invaluable for repairing defective spots in flooring. The Smooth-On Co. will be pleased to send one of its concrete catalogs to anyone sending his name and mentioning Practical Engineer.

OWING TO THE RAPIDLY increasing business in C. H. Wheeler high-vacuum condensers, pumps and feed-water heaters, involving demands upon the present plant beyond its capacity, the C. H. Wheeler Manufacturing Co. has recently purchased a lot 400 by 150 ft. and adjoining its Sedgley Ave. property in Philadelphia. On this land will be erected an additional machine shop; to be equipped with 30 and 10-ton overhead cranes, together with electric hoists and the latest electric driven machine tools, which will increase the output 50 per cent; it should be completed by September.

Sparks From The Advertising Pages

DOWN in a little Pennsylvania city, there lived two young men—both bright, ambitious and industrious. They were employed in the two power plants of the town as assistant engineers, and it was a toss-up as to which of the two had the best chance for landing an engineer's berth first.

They were chums—these two young fellows—but that didn't prevent either of them from trying his best to out-do the other. Each worked hard and faithfully and each studied the situation at his plant, searching for ways by which an improvement might be made.

Both young men read their power magazine regularly and thoroughly. Not an article escaped them—they were on the lookout for anything that might be of help in landing them in that coveted engineer's berth.

One day one of the young men noticed an advertisement of a device that made old valves like new—noticed it the very day after the engineer and he had spent a weary afternoon in replacing half a dozen that were failing to do their duty.

He called his chief's attention to the advertisement and the chief spoke to the purchasing agent. The device was sent for and tried. It proved to be a big labor saver and it cut down expenses too—cut the cost of new valves down to a mere fraction of what it had been before. As the Engineer put it "I guess that machine means an end to late hours and Sunday work—a good part of it anyway. We can take our holidays now without feeling that we ought to put the time in fixing up bad valves."

The Engineer was promoted later—became superintendent. When his new job came, he remembered the incident of the leaky valves and he recommended his assistant for his old position as engineer.

The purchasing agent remembered too, and frequently he comes around to get suggestions from the former young assistant.

The other young man will get there too—someday. His hard work and conscientious attention to duty will win out in the end. But he missed one of his opportunities. He thought that the good of his magazine ended with its news pages. He knows better now. His friend put him wise. He reads the advertisements too.

AN ATTRACTIVE 16-PAGE condensed catalog describing its various lines of condensing apparatus has just been issued by the Wheeler Condenser & Engineering Co., of Carteret, N. J. In a preface entitled "Condenser Engineering" it is pointed out that each condensing equipment is a problem in itself, and that it is necessary that there be a wide range of designs of condensers, cooling towers, pumps, etc., in order to provide combinations of such apparatus which will meet the requirements of load, vacuum, water, temperature, supply of water, etc., at the highest efficiency and least operating cost. Copies of this Condensed Catalog may be obtained upon application to the Company.

FROM THE CRAWFORD Publishing Co. of Chicago comes the Engineering Directory for 1912. This is a 1500-page book of 4 by 7 in. in leather binding containing lists of jobbers and dealers in mill and factory supplies and machinery, jobbers of plumbing and heating supplies, wholesalers in hardware, wholesalers in electrical supplies, manufacturers' agents in these various lines, manufacturers, purchasing agents of railroads, architects, for United States and Canada, and lists of power and lighting plants and classified list of manufacturers of the lines above mentioned for the United States. These lists are very complete, well arranged, in clear type and convenient form and have a full cross index to articles of manufacture. The price is $5.

THE WILLEY ELECTRICALLY DRIVEN TOOLS, made by James Clark, Jr., Electric Co., of Louisville, Ky., are fully illustrated and described in a 50-page catalog.

PRACTICAL ENGINEER CLASSIFIED ADVERTISEMENTS

Advertisements in this section are inserted under regular headings at the rates of 30 cents per line. About nine words make a line. No display type allowed, but the first three words may be set in capital letters. Minimum space sold, two lines.

Under classification, "Positions Wanted," advertisements not exceeding four lines will be inserted for subscribers once free of charge.

To insure proper classification, copy must reach this office 10 days preceding publication.

Positions Wanted

POSITION WANTED—As engineer, by man 26 years of age, having 5 years' experience with Corliss and high speed engines, alternating and direct current dynamos, boilers and pumps. Can do line work. Strictly sober and steady. 4 years in plant where at present employed. Address Box 211, Practical Engineer, Chicago, Ill. 3-15-2

POSITION WANTED—As manager or superintendent of an electric lighting and power plant, in city of from 2,000 to 10,000 inhabitants. Have the education and experience and also the mechanical and business ability to get results. Address Box 212, Practical Engineer, Chicago, Ill. 4-1-1

POSITION WANTED—As engineer in a small plant. Have had experience with Corliss engines. D. C. generators. No bad habits. Good references. 30 years old. Will go any place at once. Address Box 213, Practical Engineer, Chicago, Ill. 4-1-1

POSITION WANTED—As gas engineer in large plant or chief engineer in small plant. Understand A. C. and D. C. machines. No bad habits. Good references. Age 31. Munzel Plant preferred. Address Box 215, Practical Engineer, Chicago, Ill. 4-1-1

POSITION WANTED—In New England, by chief engineer with 22 years' experience on high speed and Corliss engines. A. C., D. C. Best references. Address Box 232, Warren, R. I. 4-1-1

POSITION WANTED—As chief engineer in small electric plant or as assistant in a large one. Ten years' of practical experience. Good references as to honesty and ability. Please state full details in first letter. Address Chas. White, 739 Montgomery St., Syracuse, N. Y. 4-1-1

Help Wanted

COMPETENT AND EXPERIENCED stoker erectors at once. State age, experience, reference and salary expected. Give full details. Address Box 168, Practical Engineer, Chicago, Ill. tf

HELP WANTED—ENGINEER WANTED in every city and town to instruct our customers in indicator practice. If you have a fair working knowledge, we will "do the rest." Good pay to reliable, intelligent men. Write for particulars. Lippincott Co., Newark, N. J. tf

ENGINEERS AND MECHANICS—To make big money selling incomparable "ZIZ" Hand Soap. A 10-cent can will instantly remove more dirt and stains from the hands than than four cakes of any soap made, and will not injure the most delicate skin. Small sample free. Byram Mfg. Co., Box 3133, Boston, Mass. tf

AGENTS WANTED TO HANDLE ESTABLISHED steam specialty which is known all over the country. Can be handled with non-conflicting specialties. Will give exclusive agency only for amount of territory actually covered by agent or his salesmen in the following states: Virginia, North Carolina, South Carolina, Oklahoma, Wyoming, Georgia, Arizona, New Mexico, Montana, Idaho, Florida, Arkansas, North Dakota, South Dakota. Address Post Office Box 1754, Pittsburgh, Pa. 9-tf

Wanted

IF YOU ARE a night engineer, spend a few hours each day taking subscriptions for Practical Engineer. You will be paid well. Write the Subscription Dept. They will start you in at once. tf

WANTED—5,000 STATIONARY ENGINEERS to send us their name and address. A good proposition open to each one. For full particulars, write Henry W. Lord, 7 S. Greene St., Baltimore, Md. tf

WANTED—THOROUGHLY COMPETENT experienced mechanical rubber salesman for the city of Chicago. Must have an acquaintance amongst the large buying trade. State age and experience, also give references. Address Box 814, Trenton, N. J. 4-1-2

WANTED—EVERY ENGINEER to have our pamphlet for setting valves on Corliss Engines, simple and compound, with one and two eccentrics Sent free. Lindstrom's Machine Works, 200 South Third St., Allentown, Pa. tf

For Sale

FOR SALE—INDICATOR, REDUCING WHEEL, planimeter, best make, in fine order. Examination allowed before payment. Price low, in fact a sacrifice. Address Mrs. N. L. Browning, East Orange, N. J. tf

FOR SALE—1 50 KW. ENGINE TYPE UNIT, consisting of an Ideal, 12x12 high-speed engine, direct-connected to a Western Electric, 6-pole, 50 KW. 275 RPM. 110/125-volt, compound wound, D. C. generator. In first-class operating condition. Can be shipped immediately. A bargain. Address Box 214, care of Practical Engineer, Chicago, Ill. 4-1-1

Patents and Patent Attorneys

PATENTABLE IDEAS WANTED—Send for 3 free books. R. B. Owen, 28 Owen Bldg., Washington, D. C. tf

PATENTS—H. W. T. Jenner, Patent Attorney and Mechanical Expert, 608 F. St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had and the exact cost. Send for full information. tf

PATENTS—C. L. Parker, Attorney-at-law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the inventors Handbook for investors sent upon request. 186 McGill building, Washington, D. C. tf

Miscellaneous

MAKE MONEY on the side. Here's your chance to pick out some money for yourself. Get subscriptions for Practical Engineer. It pays well. Just drop a line to the Subscription Dept. They will tell you how. tf

EVERY ENGINEER should be posted regarding the new system of vacuum heating installed without payment of royalty; I have valuable information; write to-day. M. Y. C., 1413 W. Jackson Blvd., Chicago, Ill. tf